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THE AUTOMOTIVE INDUSTRY AND THE DIESELGATE CASE

Faculty of Management and Business

Master's Thesis

December 2019

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ABSTRACT

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Master's Thesis
Tampere University
Degree Programme in Public Economics and Public Finance (MGE)
December 2019

In the last few years, environmental pollution and especially vehicle pollution has been the subject of numerous debates all over the world. Following the scandal on the handling of emissions from diesel vehicles through the installation of defeat device systems by the Volkswagen Group, the attention on Diesel engines and especially on the severity of the emissions produced by diesel fuel has become more and more remarkable.

The aim of this thesis is to explain the differences between the various types of engines on the market, the consequences caused by the polluting substances emitted by the vehicle exhaust pipe and the events that led to the detection of the fraud implemented by the Volkswagen Group. Furthermore, a survey was carried out on with the aim to try to understand consumers' perception of vehicular pollution, propensity to use engines powered by alternative energy sources instead of diesel engines and the grade of awareness regarding the Volkswagen case. Finally, in order to try to get answers on the future of the automotive market and especially on the future of diesel vehicles, an analysis was made of the forecasts and statistics made by automotive industry analysts.

Keywords: Automotive industry, pollution, Dieselgate, Volkswagen, emissions

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Introduction

In the last twenty years, vehicular mobility has made huge progresses, becoming a very useful tool for the development of modern societies. Nowadays, the automotive industry is in a position of extreme importance in the world economy and gives a significant contribution to the evolution of societies. However, despite the several advantages that road vehicles can offer to the population, there are just as many disadvantages due to the emissions produced by vehicle exhaust gases. The emissions produced by the combustion of fuels of both diesel-powered and petrol-fueled engines increase in proportion to the constantly growing population increase. The increase in population leads to a consequent increase in the demand for mobility and therefore for motor vehicles. Among the main polluting elements produced by vehicle exhaust gases, especially it has to be reminded Carbon dioxide (CO_2), Nitrogen Oxide (NO_x) and Particulate Matter (PM). These three substances represent the most harmful ones for human health and for air pollution. The engines of petrol-powered vehicles have a prevalence of CO_2 emissions while diesel-powered engines have lower CO_2 emissions but a high rate of NO_x. In recent years, NO_x emissions from diesel vehicles have alarmed governments around the world due to the severity of the effects caused to the environment and human beings, which are much more serious than those caused by CO_2. Over the past 15 years, people have become increasingly aware of environmental issues, which has led States and organizations worldwide to take measures to limit the damage caused by industrial production. The imposition of pollution standards has led industries to move towards eco-sustainable production and products. Nowadays, the introduction of Corporate Social Responsibility policies in production processes and the adoption of managerial strategies to produce green products has become a highly competitive tool for companies. In the automotive industry, the production of eco-sustainable cars has become a dynamic challenge that involves the use of costly resources and competitiveness puts a strain on automotive companies that cannot adapt. Consequently, the reduction of polluting emissions including CO_2 and NO_X represents a challenge in constant evolution for the automotive companies both for the imposition of standards and for the awareness of consumers towards vehicular pollution. However, the adoption of eco-sustainable practices represents high costs in terms of resources and time for companies (Chiara Valentini & Dean Kruckeberg, 2018, p.528-529). Europe is one of the largest car manufacturers in the world and the European automotive sector employs the largest number of workforces. In addition, the automotive industry contributing substantially to the EU economy (Chiara Valentini & Dean Kruckeberg, 2018,

p.530). In Germany, the giant carmaker Volkswagen plays an extremely important role as it represents the largest business of the state by far. Currently Volkswagen is one of the companies with the largest number of employees worldwide in the private sector, counting a total amount of 664,496 workers. In Germany the company records the largest percentage of its workforce (44%) and indirectly it creates hundreds of thousands of jobs all over the world. Indeed, although The Federal State of Lower Saxony has a minority stake in the VW Group, it holds a privileged voting right position in the shareholders' meeting. Over the years numerous German political figures have been part of the Volkswagen group's board of directors and in fact the automotive group could be defined as a semi-state company (Volkswagen.com, Blažek L. & Vlastimil S., 2018). In September 2015 the Volkswagen Group was accused by the US Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) of having installed defeat device systems on the so-called “Clean Diesel” engines of the 2.0 TDI and 3.0 TDI models produced and sold between 2009 and 2015. The installation of the defeat device systems on each of the diesel engines produced by Volkswagen made it possible to deceive the type-approval tests of the vehicles by producing results conforming to the standards imposed by the law while in normal driving conditions the vehicles emitted exhaust gasses 40 times greater than the limits allowed in the United States. In the overall, the VW Group installed 11 million emissions tampering software on their diesel vehicles worldwide, 590,000 of which in the United States. This was one of the most important automotive frauds in the world. The automaker was accused of fraudulent conspiracy against the United States of America and American consumers and violation of the Clean Air Act (CAA). At the very beginning, the sanctions and damages caused by the fraud disclosed by the Notice of Violation (NOV) published by the EPA in June 2015, led to a drastic drop in sales and stock prices of the automotive group. However, despite the various negative forecasts by automotive industry analysts who argued that the VW Group would never recover from the scandal-driven crisis, by mid-2016 the company had significantly recovered both sales and share prices (Jung JC & Sharon E., 2019, p.6). Following the Volkswagen scandal, many governments have begun to investigate the emissions produced by other car manufacturers. They discovered that the German automotive group had not been the only one to use manoeuvres to evade the law. As a result, several governments have decided to adopt increasingly stringent control measures and much stricter standards to limit as much as possible the damage caused by NO_x. To get a clearer idea of consumers' perception of environmental pollution, diesel engines, Dieselgate and to understand their future

consumption decisions, a survey was conducted based on an online questionnaire. The results showed that to date the number of consumers who own a diesel-powered vehicle is still high despite the various debates. However, the propensity to future consumption is strongly influenced by a sense of moral duty towards the environment and many people have claimed to want to orientate themselves towards the purchase of cars powered by alternative energies. Finally, several analyses carried out by experts in the automotive industry have advanced hypotheses and forecasts regarding the future of traditional diesel and petrol engines. From the statistics, it seems that the diesel has for some years now begun to lose important market shares, making room for more and more engines powered by petrol and partly by alternative energy. Following the emissions scandal of the car manufacturer Volkswagen, the company implemented a new strategy based mainly on investing substantial capital for the production of electric vehicles.

Chapter 1 Vehicular pollution: theoretical elements

The aim of this chapter is to briefly introduce the protagonists of this thesis: the automotive industry and vehicular pollution. Considering the complexity and the vastness of the information related to these two topics, in the following paragraphs I will try to introduce a basic idea of both in order to build the frame for the understanding of the following chapters. The automotive industry represents a huge part of today's economy and it is also an important provider of our independency, an engine of the society's growth and one of the protagonists of the industrial revolution. Nowadays there are several brands that provide the society with a vast selection of vehicle models, different types of engines, various performances, meeting the very need of everyone. However, it is important to keep in mind also the dark side of this phenomenon that is the damage produced by motor vehicles. Pollution is a phenomenon that involves many concepts and there are several factors that affect human health and the environment. Our planet isn't polluted just by human activities, there are also natural origins such as methane produced through animals' digestion (especially cows), or volcanic activities which produce ash particles, Sulphur and chlorine. On the other hand, pollution man-made[1] represents the main problem since it has achieved unbelievable levels and the concentration of toxic substances in the atmosphere represents a noticeable issue worldwide.

[1] The technical term is "Anthropogenic".

The exhausts emitted by road vehicles and produced through the combustion of fossil fuels, represent a high rate of the total amount of man-made pollution. Nowadays, most light vehicles and trucks are powered by diesel or gasoline fuels. Diesel fuel is the protagonist of the scandal that gave rise to the so-called "Dieselgate" case. The end of this chapter will discuss about the main damages that vehicular pollution cause to human health and to the environment that we are leaving as a legacy to future generations.

1.1 Automotive industry

Table 1.1 Geographic distribution of cars production, ten years variation 2008 - 1018

Continent	Y 2008	Y 2018	Variation	Difference
Europe	21.770.785	21.272.561	-2% -	498.224
America	16.916.515	20.727.528	18,39%	3.811.013
Asia	31.256.384	52.266.852	40,20%	21.010.468
Africa	582.847	1.125.636	48,22%	542.789
Total	**70.526.531**	**95.392.577**	**26,07%**	**24.866.046**

Source: Adapted from OICA, various years. http://www.oica.net/production-statistics/

For several years now, mobility represents a necessity and a need for humanity. With the arrival of the industrial revolution, people have increasingly begun to feel the need to be able to move from one place to another both for work and personal reasons. Nowadays, road vehicles such as cars and motorcycles allow us to move freely and independently; public transport such as buses allow the population to reach their place of work or destination preferably without a driving license; trucks allow the transport of goods and products that we find in supermarkets and shops every day. Nowadays, the automotive industry has become of fundamental importance for society and for world innovation (Eriksson, Nielsen, p.4). The automotive industry is a huge sector and defining it in detail in a single paragraph is completely impossible. However, the main idea in this section is to provide an overview about the global automotive industry in terms of production, sales, market size, car use and social status related to owning a car. The phenomenon of globalization has led the automotive industry to grow more and more rapidly over the years. Besides, globalization allowed the industry to adapt to increasingly dynamic and demanding markets, leading to rapid changes and technological developments. It is important to underline that at global level there is no single undifferentiated market for the automotive industry.

In fact, depending on various factors including geographical location, climatic conditions, current regulations, cultural and socio-economic differences, the automotive industry will produce specific types of cars to meet consumer needs (Nieuwenhuis & Wells, p.21). In order to satisfy every need, the automotive industry provide a vast category of cars in terms of shape, dimension, engine and fuel type. The macro-categories of vehicles can be summarized in passenger cars, light commercial vehicles and trucks. Then, another distinction could be in passenger cars that are segmented in mini, small, lower medium, medium, upper medium, luxury, sport, van, SUV/off-road, others (Icct, pocketbook 2018/19, p.17). Table 1.1 shows the data relating to the production of vehicles based on the geographical position with the variation in production that took place over the last ten years. Global production by 2018 was 26% higher than in 2008, with a total of 95 million cars produced worldwide. Asia is the continent with the highest production both in 2008 (ten years ago) and in 2018. The remarkable increase in production that Asia has had in ten years is very interesting, a good 40% more than in 2008. China is now the largest car manufacturer in the world, with almost 28 million cars produced in 2018 exceeds the share produced by both America and Europe (OICA, 2018). On the other hand, Europe registered a production deficit of 2% with almost 500,000 cars produced less than in 2008. However, table 2.2 and figure 2.1 show us that there has been a noticeable decline in car sales between 2007 and 2010.

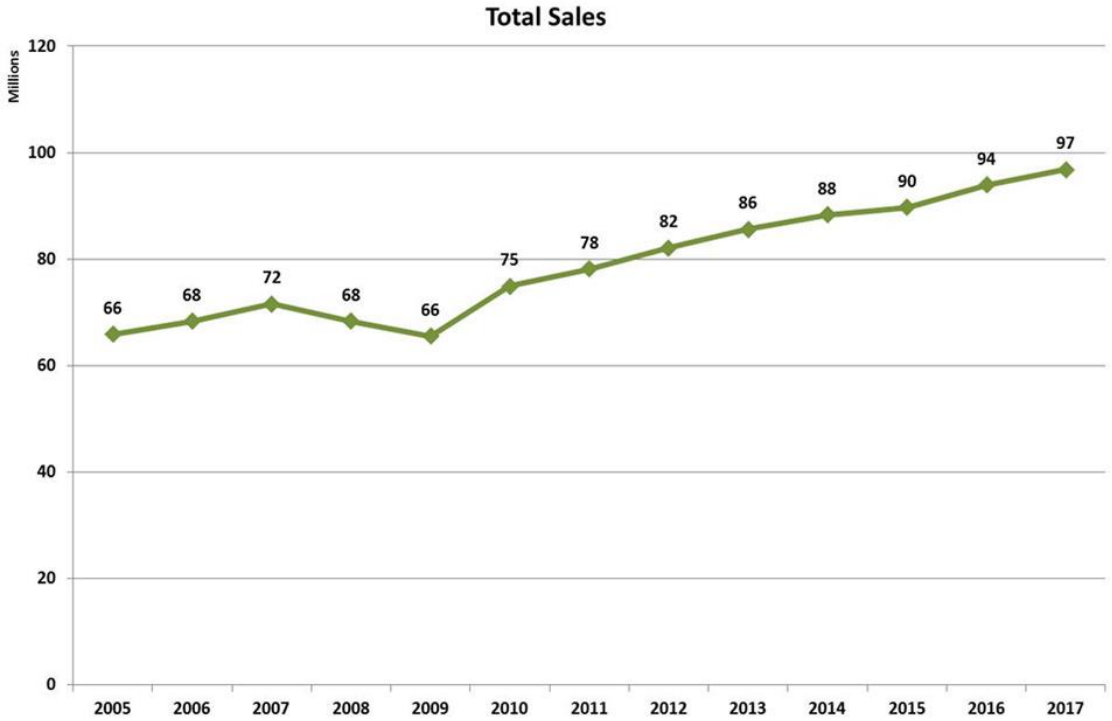


Figure 1.1 Total new cars sale from 2005 to 2017 (Source: OICA, various years)

This instinctively leads us to think that the drop could be due to the financial crisis that occurred in that period, but this has no prevented the automotive industry from recovering very quickly following that episode.

Table 1.2 Geographic distribution of new cars sales, 2005 - 2017

Y	Europe	America	Asia	Africa	Total
2005	21.063.326	23.338.854	20.402.735	1.113.017	65.917.932
2006	21.863.840	23.356.675	21.812.560	1.314.275	68.347.350
2007	23.006.722	23.609.065	23.619.274	1.321.974	71.557.035
2008	21.872.430	20.902.901	24.277.072	1.255.851	68.308.254
2009	18.645.351	17.497.045	28.261.495	1.158.774	65.562.665
2010	18.808.688	19.719.981	35.179.084	1.251.221	74.958.974
2011	19.740.019	21.578.039	35.392.386	1.446.927	78.157.371
2012	18.663.178	23.670.893	38.212.928	1.569.463	82.116.462
2013	18.343.409	25.030.005	40.567.306	1.653.587	85.594.307
2014	18.587.650	25.475.531	42.544.518	1.717.921	88.325.620
2015	19.035.989	25.688.159	43.405.639	1.577.535	89.707.322
2016	20.134.829	25.551.912	46.903.730	1.315.163	93.905.634
2017	20.916.025	25.788.942	48.903.658	1.195.765	96.804.390

Source: Adapted from OICA, various years. http://www.oica.net/category/sales-statistics/

In table 1.2 we can also see that the financial crisis has only affected Europe and America, while Asia has seen increasing sales and Africa a stable market. Moreover, in this case it is surprising to see that from 2005 to 2017 Asia sales more than doubled, switch from 20 million sales in 2005 to 49 million in 2017. On the other hand, Europe fell slightly over the same period. However, the International Council on Clean Transportation (Icct) in his last report regarding the European vehicle market, claims that in 2017 EU registered the highest level of car registration since 2007. The European market of new cars registered has long been dominated by Germany which represent 23% of the EU market. Germany has had a drop in market share in 2006 – 2008 recovering in 2009 thanks to a government scrappage scheme that leads the automotive market of the country to a rosy period. Nowadays, it is still the largest market in Europe registering around 3.4 million new cars per year (Icct, pocketbook 2018/19, p.15). These data could mean that the automotive market is rapidly recovering from the various crises which have affected the whole economic and financial system worldwide in the past years. In the other hands, is surprising to notice that the automotive industry is

growing extremely rapidly, and the cars produced every year reach unimaginable numbers. It comes then naturally wonder if the infrastructure and road capacity will be able to adapt to

Table 1.3 **World ranking of manufacturers Year 2008**

Rank	Group	Total vehicles
1	TOYOTA	9.237.780
2	GM	8.282.803
3	VOLKSVAGEN	6.437.414
4	FORD	5.407.000
5	HONDA	3.912.700
6	NISSAN	3.395.065
7	PSA	3.325.407
8	HYUNDAI	2.777.137
9	SUZUKI	2.623.567
10	FIAT	2.524.325

Source: Adapted from OICA, http://oica.net/wp-content/uploads/world-ranking-2008.pdf

Table 1.4 **World ranking of manufacturers Year 2018**

Rank	Group	Total vehicles
1	VOLKSWAGEN	10.810.349
2	TOYOTA	10.435.420
3	RENAULT NISSAN	10.346.982
4	GM	8.643.003
5	HYUNDAI	7.416.346
6	FORD	5.632.734
7	HONDA	5.234.818
8	FCA	4.825.446
9	PSA	4.084.845
10	SUZUKI	3.306.242

Source: Adapted from Focus2Move, https://focus2move.com/world-car-group-ranking/

this constant growth for a long time and if this growth will ever reach a peak.

Over the years numerous brands emerged to the market proposing new models of car with innovative technologies and performance, various shapes and design. The very basic need of mobility was overpassed quite rapidly and the difference through car manufacturers start to be represented by innovation, originality and relation between costs and performance. Over the years some classifications have been drawn up which illustrate the major manufacturers of the automotive industry with the largest market shares worldwide. In 2008, table 1.3 shows that the main competitors on the world market were respectively Toyota, General Motors, Volkswagen, Ford and Honda. Ten years later, Table 1.4 shows us that in 2017 Volkswagen has grown of one position surpassing GM while Toyota represented still the world's largest vehicle manufacturer. Besides, from the previous two table (Table 1.3 and 1.4) is interesting to notice as Hyundai has passed from the eighth position in 2008 to the third position in 2017 with an impressive growth about 4.4 million cars. However, it is important to consider that over the years many things have changed in the automotive industry and many brands have merged into one large group (such as the Chrysler Group which in 2014 welcomes 100% of Fiat's holdings, giving life to the new FCA group). The various automotive groups are dynamic and constantly evolving, which is why a temporal comparison between groups gives unclear results on the dynamics of change.

The European Automobile Manufacturers Association (ACEA) argues that the automotive sector recorded 6.8% of European GDP in 2015 with a return on taxes of 413

billion euros. Furthermore, the European automotive industry provides employment for 13.4 million people in 2016, or 6.1% of total European employment (ACEA). However, in the analysis carried out by Paul Nieuwenhuis and Peter Wells in their book "The global automotive industry" (2015) it appears that mobility through people's motoring expressed in miles traveled is in continuous decline. Furthermore, it is pointed out that this decline began before the 2008 financial crisis explaining that the reasons are not entirely to be reported to this event (p. 22). One of the reasons that could explain this phenomenon, say Paul N. and Peter W. could be linked to the fact that the population is facing a decrease in the percentage of young people who own a driving license or a car (p.24). Another reason mentioned in the book could be related to the urbanization of people, which leads them to use cars less for reasons of traffic congestion in the cities. This decline in mobility could be an indicator that suggests that the usefulness of driving is probably decreasing. People could be discouraged by various factors such as the increase in parking costs, increased fuel consumption, bad road conditions or increased traffic which slows down the time to reach destination destinations, taxes and insurance. Furthermore, the possibility to take advantage of low-cost flights reduces the use of cars for longer journeys but also the increase in home deliveries of products and services is another factor that allows people to renounce the possession of a car. However, despite the above, the decrease in the use of cars for the mobility of people does not explain the constant increase in sales of cars that is recorded every year. Paul N. and Peter W. argue that the possession of a car has become a very important thing for people, and they are not from the point of view of utility but also for the status that such possession gives to people. In their study, they claim that many people interviewed stated that they had waived some personal expenses to afford to keep the costs associated with their car (p.25). This could be a good reason to explain the inconsistency between the decrease in car-driven miles and the increase in sales in the automotive industry.

1.2 Engines and vehicular energy

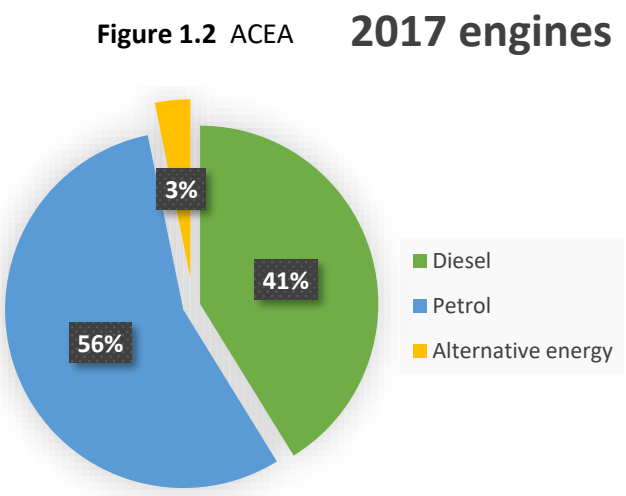


Figure 1.2 ACEA

Nowadays the automotive industry produces different types of engines. However, all the engines use chemical energy that is transformed inside the engine itself into mechanical energy which allows the use of vehicles (G. Genta et al. P.313). Most vehicles in circulation today use fossil fuels as a source of energy but sometimes cars with alternative energy can also be seen circulating (G. Genta et al. P.485). In 2017 the ACEA (European Automobile Manufacturers Association) recorded 96.8% in the use of internal combustion engines (41.2% Diesel and 55.6% Petrol) against 3.2% of alternative energy engines (Figure 1.2). The first internal combustion engine was invented in 1854 by Eugenio Barsanti and Felice Matteucci but the sudden death of Barsanti in Lieges prevented the two partners from completing any commercial success. The first successful company that decided to start producing and selling ICE engines was that of Jean Joseph Lenoir (G. Genta et al, p.81-84). The engines (ICE) mix air[2] and fuel together in order to produce energy and emissions. The oxygen present in the air allows to oxidize the fuel and therefore the production of energy. Usually internal combustion engines are based on hydrocarbons (Eriksson & Nielsen. P.69). Most of fuels are composed by coal and hydrogen and some fuels also contain oxygen. Internal combustion engines can be powered by Diesel, petrol, methane, LPG and hydrogen. However, the internal combustion engines most commonly used by the population nowadays are also those with a higher level of pollution, i.e. those fueled by diesel and petrol. There is a close relationship between fuel[3] consumption and CO2 emissions; in fact, they are directly proportionate: CO2 emissions increase with the increase of the fuels consumption. However, there are some fuels such as methane[4] which unlike diesel and gasoline produce less CO2 (Eriksson & Nielsen. P.71). An important difference between a

[2] In that case "air" means a set of gases including nitrogen, oxygen, water, argon, carbon dioxide and other molecules.

[3] Fuel and combustible substances are not synonymous; all fuels are combustible substances; liquid or gaseous hydrocarbons, hydrogen and derivatives of vegetable compounds such as alcohols derived from carbohydrate fermentation are included in the fuel category. Both fuel and combustible substance react with oxygen to burn.

[4] Methane is a natural gas.

diesel-powered and a petrol-powered engine is that the fuel injection is directed into the port for petrol engines while for the diesel engines the fuel injection is directed into the cylinder (Eriksson & Nielsen. P. 79). Internal combustion engines are mainly divided into two categories explained below (G. Genta et al, p.313):

• Spark-ignition engine (SI engine);
• Compression ignition engine (CI engine).

The Spark-ignition engine (SI engine) is powered by gasoline which is sprayed and mixed with air in order to produce energy (G. Genta et al. P.79). This category of engines can have either direct or indirect ignition (G. Genta et al p.313). On the other hand, the Compression ignition engine (CI engine) is powered by diesel. The fuel passes through three phases inside the engine before producing energy: ignition delay, premixed combustion and mixing controlled combustion. In the first phase the diesel is transformed by a liquid and cold consistency into steam which will then be self-injected. In the second phase when the steam reaches the proper temperature it will be injected and burned. In the last phase the fuel is combined with air and burned for energy generation (Eriksson & Nielsen, p.126). SI engine is usually preferable by consumers for reduced emissions, lower noise emissions and low costs. The CI engine instead is preferred because it is more fun to drive and for lower costs in terms of fuel (G. Genta et al. P.315). Why, despite the damage caused by fuel from internal combustion engines, do people continue to buy ICE vehicles? The factors that influence consumers in their choice when they have to buy a car in terms of motorization are many: type of engine power supply compared to the cost of fuel, emissions and noise, maintenance and periodicity of the maintenance, useful life of the engine, performance of the vehicle. Eriksson & Nielsen argue that another important aspect of consumer decision is the speed with which the engine converts fuel into energy (p. 74 -75).

The electric car was one of the first vehicles to be invented and dates back to the 1800s. Charles Jeantaud was one of the largest automobile manufacturers in France between 1800 and 1900 and it was he who brought the first electric cars to market (G. Genta et al., P. 140-141). At that time electric cars were more widespread in the United States than in Europe due to a number of factors, including the increased use of cars by women[5] and greater urban concentration. The automotive electric car industry began to lose important market shares

[5] Women preferred to drive electric cars instead of fuel-powered cars because they were easier to drive.

starting from 1912 with the arrival of internal combustion cars that solved one of the biggest problems of electric cars or start-up (G. Genta et al. P. 144 -145). However, despite the fact that vehicles with electric motors represent a niche market in the automotive industry today, the demand for this type of car is gradually increasing due to a series of factors. The most significant of these factors is that cars powered by electricity have a very low impact on pollution. However, the main disadvantage of these cars is their poor performance in terms of engine and battery. Furthermore, cars powered by electric batteries are very expensive and the size of the batteries is quite large (G. Genta et al. P.485). In fact due to the large dimensions and their weight, electric batteries are difficult to replace and to manage for those who own an electric car. Electric cars are therefore powered by the electricity contained in the batteries which is converted to generate useful energy for the vehicle's traction. The batteries of this type of engines are recharged by external resources (Eriksson & Nielsen. p.48). In the "Global EV Outlook 2018" published by the IEA (International Energy Agency), a stock of 3.109.05 million electric cars is registered worldwide with the highest concentration in China, which records 1.227.77 million (p.107) . The growth in the sale of new electric cars has been remarkable over the years. In 2005, sales worldwide totaled 1.89 million while in 2017 they grew to 1.148.70 million. There may be a slight decrease between 2006 and 2007 probably due to the financial crisis (Global EV Outlook 2018, p.109). Nowadays, the automotive industry provides also hybrid vehicles that have two engines, both an internal combustion engine and an electric one.

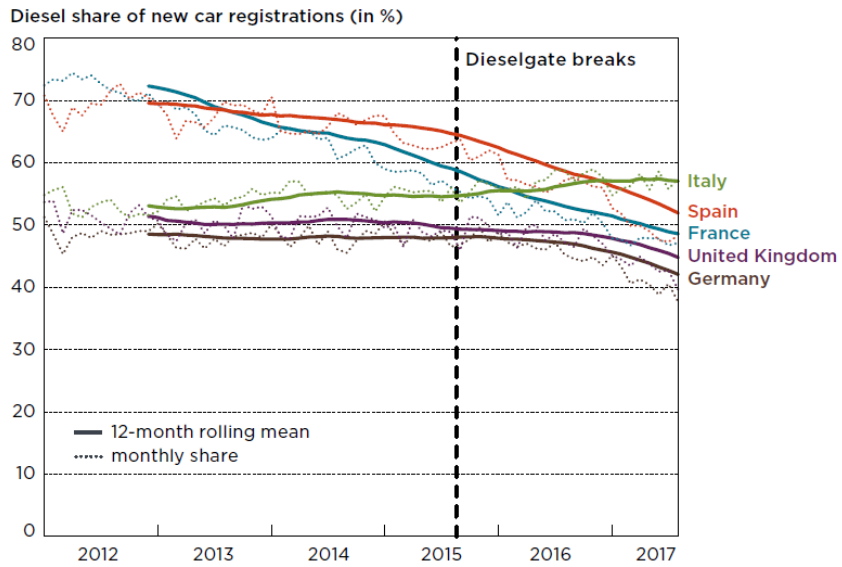


Figure 1.3

The market share of car powered by diesel in Italy, Spain, France, UK and Germany. (Source: Icct, https://theicct.org/sites/default/files/publications/ICCT_Pocketbook_2017_Web.pdf

Europe represent the continent which sold the higher amount of diesel cars worldwide (65% of cars powered by diesel worldwide). The Dieselgate scandal made the market of diesel cars extremely complicated. European registrations have always been dominated by diesel cars, indeed until 2012, 55% of cars sold in Europe was powered by diesel fuel. However, when the Volkswagen scandal surfaced, the sales of diesel cars in EU slowly started decreasing, in 2016 the market share of diesel reached 49% of cars registered in the continent. However, as we can see in the figure 2.3, the market share was very different depending on the country. Indeed, in France, for example, the diesel cars registered was significantly higher than the EU average. Instead, in Germany, the market share of diesel didn't change too much in the past five years before the scandal. Italy is the only country which has increased his market share of diesel cars over the years, also after the Dieselgate scandal (Icct, pocketbook 2017/18, p. 3).

1.3 Vehicular pollution

Over the last few years the considerable increase in industries, the expansion of cities and the numerous human activities are gradually increasing atmospheric pollution. Nowadays, the main pollutant sources are of industrial, domestic and vehicular origin. The emissions produced by vehicles for road transport of people and goods, make a significant contribution to global air pollution, representing one of the most atmospheric pollution factors. However, a huge part of the world development in the last 100 years is due to transports which allow globalization expansion and human wellbeing in terms mobility. Indeed, vehicular pollution occurs mostly in urban cities where traffic is more concentrated and industrialization is at high levels[6] (Khare, Nagendra et al., p.7). Wark and Warner define air pollution as

> *[…]the presence in the outdoor atmosphere of one or more contaminants or combinations thereof in such quantities and of such duration as may be or may tend to be injurious to human, plant, or animal life, or property or reasonably interfere with the enjoyment of life or the environment.*

With the growing and constant desire of people for mobility and independence, the number of vehicles in circulation in recent years is reaching very high levels. Most of the emissions come from the combustion of fuel-powered vehicles (Khare, Nagendra et al. P.7-8).

[6] In the future a huge increase in air pollution is expected, especially in developing countries which will face a significant increase in the number of vehicles on the road and operating industries; see chapter five.

In fact, internal combustion vehicles produce high quantities of greenhouse gases and atmospheric pollutants. Diesel exhaust[7] contain a high and complex mixture of constituents. The harmful gaseous of diesel exhaust include, oxygen, sulfur compounds, carbon dioxide, aldehydes[8], nitrogen, carbon monoxide and several low-molecular-weight hydrocarbons (EPA 2002, p. 1-1). However, the main relevant air pollutants produced by road transport vehicles are (OECD, p.26):

- Particulate matter[9] and nitrogen dioxide (NO_2);
- Nitrogen oxide (NO_x);
- Sulphur dioxide (SO_2).

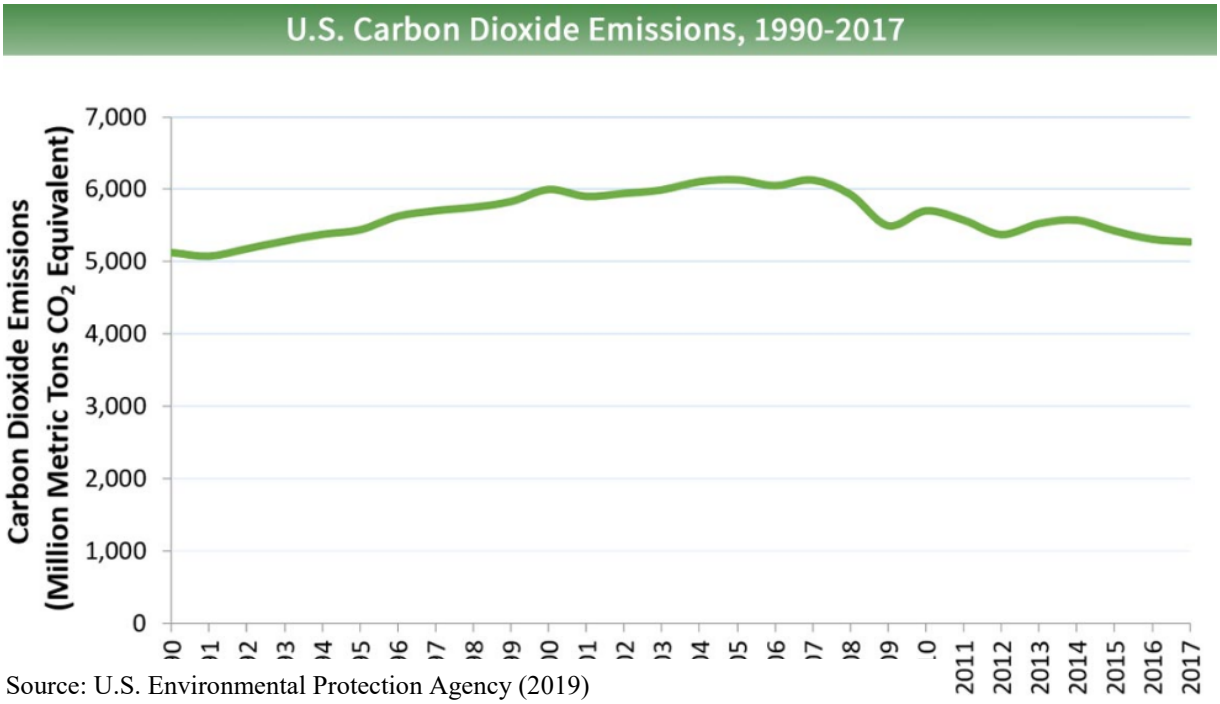
Instead, the main greenhouse gases produced by vehicles are:

- Carbon dioxide[10] (CO_2);
- Methane (CH_4);
- and nitrous oxide (N_2O).

The pollutants, as well as the most harmful to health and the environment, emitted by motor vehicles are CO_2, NOx and Particulate matter. The CO is a gas that is produced through the incomplete combustion of the fuels inside the vehicle engines. The CO_2 once issued remain in the air for at least 2 or 4 months (Khare, Nagendra et al. P.10). CO_2 does not directly pollute the air we breathe but has a significant impact on global warming and this is why their emissions must be reduced (OICA, vehicle emissions). In 2017 the amount of CO_2 registered in U.S. was about 81.6% of the total greenhouse gasses emitted by human activities. Moreover, the industry of transport (goods and people transport) represented the largest (34.2%) responsible of the total amount of CO_2 emissions in U.S.

[7] Diesel exhaust are composed both from gasses and particle.
[8] It is a gaseous hydrocarbon with high level of toxicologic relevance.
[9] PM consists of fine and ultrafine particles. “Particulate” is a term that refers to all those atmospheric substances which are not gases. PM_{10} is an example. The number beneath indicate how fine are the particles.
[10] his persistence in the atmosphere is approximately 2 – 4 months.

Figure 1.4



Source: U.S. Environmental Protection Agency (2019)
https://www.epa.gov/sites/production/files/gases-by-co2-2019-line-caption.jpg

As shown in Figure 21.4, between 1990 and 2017, CO_2 emission in U.S. increased by about 2.9%. This growth is due several factors such as economic development, growth of population, climate changes, new technologies and changes in terms of energy prices (EPA report 2019). The principle that allows the combustion of fuel on diesel engines is the same as that of petrol engines: the explosions inside the engine make the pistons move, which in turn make the transmission shaft turn. However, the diesel engine produces less carbon dioxide (CO_2) than gasoline-powered engines, on the other hand, however, the exhausts produced by diesel are much more harmful than CO_2 (Khare, Nagendra et al. P.8-9). Furthermore, as Khare and Nagendra claimed (2007, p.12) diesel-powered engines produce more PM (Particulate matter) than petrol engines. The United States Environmental Protection agency in his last report regarding the Automotive trends, registered an average of CO_2 emissions by new cars of 357g/mi worldwide level. Surprisingly, this is the lowest average ever registered (EPA report 2018). In Europe, the average of CO_2 produced by passenger cars in 2017 was about 119g/km (Icct, pocketbook 2018/19).

NOx derives from the oxidation of nitrogen during the combustion of fuels at high temperatures and their reaction increases with increasing temperature (Khare, Nagendra et

al. P.10). In particular climatic conditions, NOx contribute to the production of the so-called acid rain and to the "Photochemical Smog" (OICA, vehicle emissions).

1.4 The effects on human health

The rapid increase in population worldwide leads to a consequent increase in means of transport to satisfy the need for mobility of human beings. This rapid increase is becoming unmanageable and ensuring the safety and health of the population is an important problem that all governments should try to control. In the long-term run, prolonged exposure to pollutants presents in the air may affect respiratory, nervous, gastrointestinal, cardiovascular and reproductive systems. Air pollution is strictly related to climate change, which is mostly due to fossil fuel combustion. Protracted inhalation of pollutants produced by vehicles causes a slowdown in the transport of oxygen to the tissues as well as a decrease in the oxygen present in the blood (Khare, Nagendra et al., P.13). For decades, diesel engines have benefited from different points of view in all around the world. However, the set of gases and particulates emitted by diesel engines contain a high concentration of elements that are extremely harmful to health. Fine particulate and formation of ozone, due to the emissions produced mainly by Diesel engine exhausts, represent a noticeable health problem for society. According to the EPA (United States Environmental Protection Agency) asthma is one of the most frequent damage to human health caused by prolonged inhalation of fine particulate. In 2007, about 30 million people in the U.S. were affected by asthma (EPA, 2007, p. 1). Furthermore, people who are already suffering from respiratory and cardiovascular diseases, children and the elderly are more sensitive to the problem of pollutants. Besides, it must be kept in mind that children are doubly exposed to this risk, as they breathe 50% more air per kg of body weight than an adult do (EPA, 2002). Every year the EPA records 15,000 premature deaths due only to pollutants produced by diesel engines. Due to their small size, PMs are very easily inhalable, going to be deposited extremely deep inside the lungs as well as having high carcinogenic properties (EPA 2002, p. 1-2). The areas most exposed to that risk are urban centers and large cities, where population has elevated levels of concentration with consequent high use of road vehicles (Khare, Nagendra et al., P. 1).

A recent study published in the European Heart Journal estimated that in 2015 mortality rate from cardiovascular disease due to air pollution, amounts to 2,4 million per year worldwide, while in Europe is around 269 000. So often the impact that vehicular pollution has on human health is underestimated, however the effects of air pollution are extremely

serious. There is a close causal relationship between the mortality rate from cardiovascular diseases and $PM_{2.5}$ emissions. Particulate matter induces oxidative stress, inflammation and vascular disease that can leads the development of diabetes, atherosclerosis, hypertension and much more dysfunctions than expected (Lelieveld, Klingmüller et al., p.1590-1591).

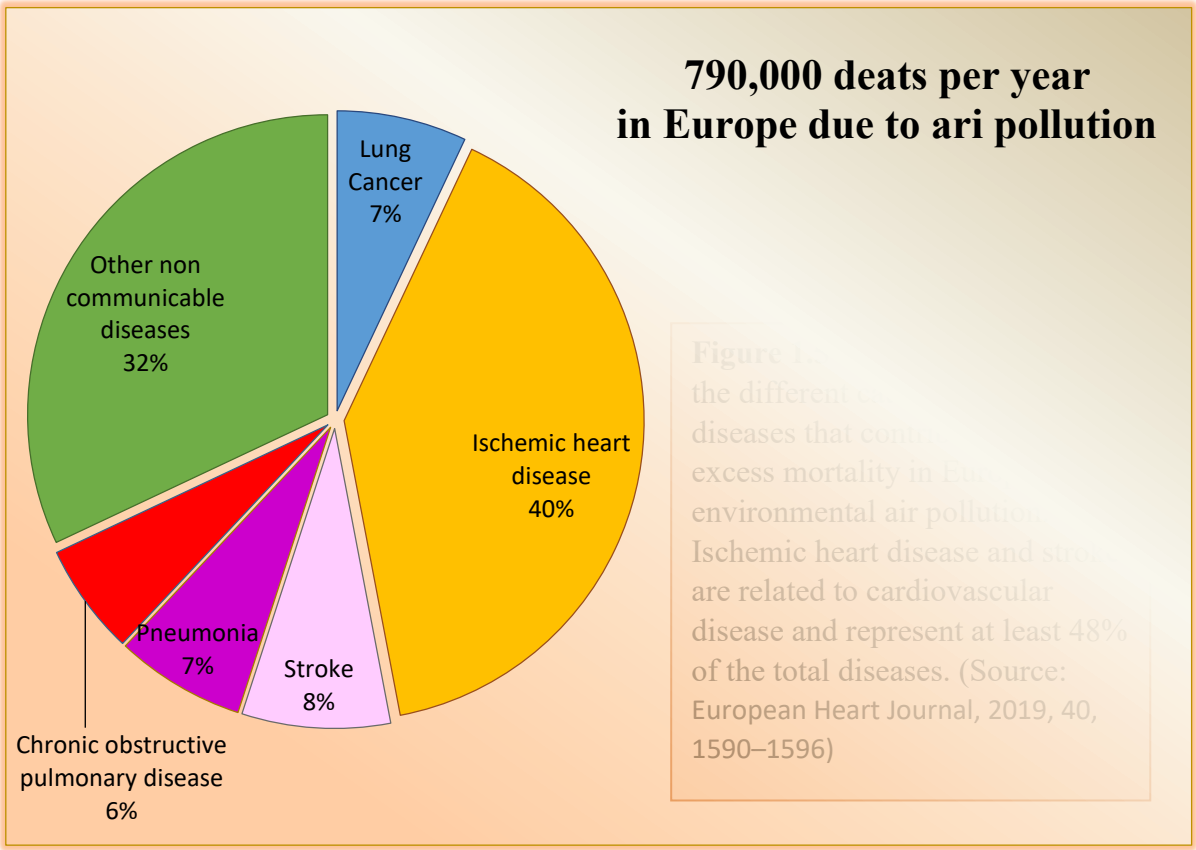
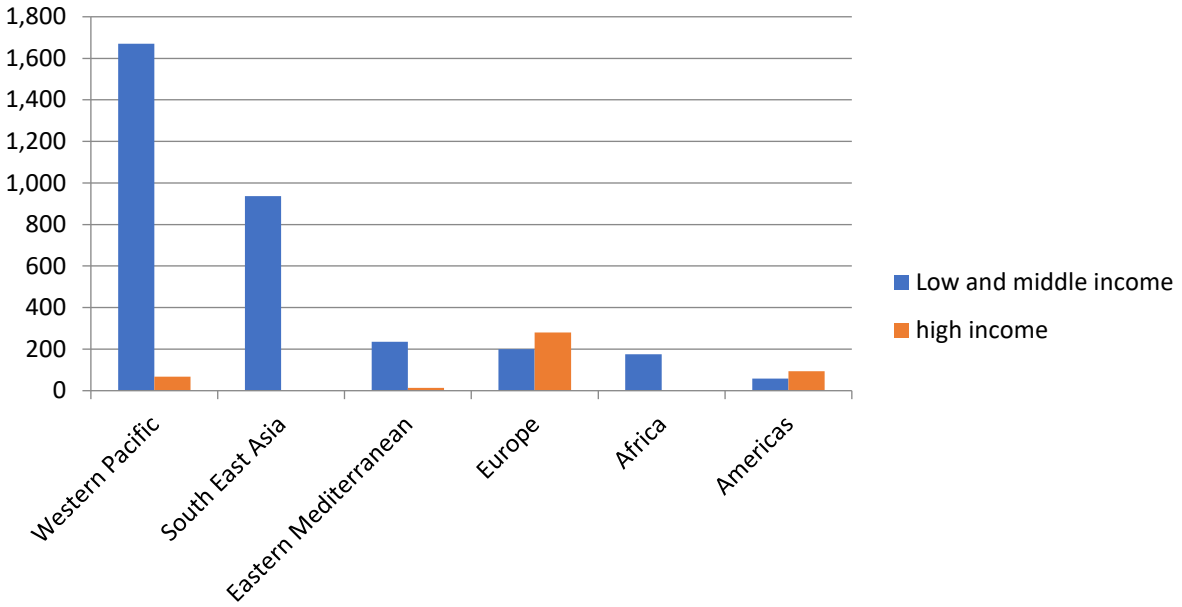


Figure 1.5 above, summarizes the main diseases caused by air pollution that leads to an annual average of 790 000 deaths only in Europe. Almost half of these diseases (ischemic heart disease and Stroke) are of a cardiovascular nature. In these times, the harmful effects on human health, due to pollutants in the air, are equivalent to excessive consumption of salt or tobacco smoke (World health organization).

Figure 1.6 Total deaths due to environmental air pollution worldwide ('000)



In 2012 the World health organization (Burden of disease from Ambient Air Pollution for 2012) estimated that 3.7 million deaths were attributable to air pollution. Most of this estimate comes from South East Asia[11] and the Western Pacific[12], about 2.6 million deaths. The Eastern Mediterranean[13] takes on 236.000, Europe 200.000, 176.000 in Africa and 58.000 in the Americas. The regions listed above are those with the highest number of populations worldwide (82%) and with a low-middle income. They represent 88% of the total mortality estimate due to air pollution. The remaining deaths are to be attributed to the countries with high incomes that record respectively 280.000 deaths in Europe, 94.000 in the Americas, 67.000 in the Western Pacific and 14.000 in the Eastern Mediterranean (Figure 1.6).

[11] Indonesia, Sri Lanka, Thailand, Timor-Leste, Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal.

[12] Australia, Brunei Darussalam, Cambodia, China, Cook Islands, Fiji, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Vietnam.

[13] Bahrain, Cyprus, Iran, Islamic Republic of, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates, Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen.

1.5 Environmental impact

However, climate pollution is not only harmful to people's health, it represents also a serious problem for planet earth. Very often we don't realize how much human activities cause irreparable damage to the planet we live. Every year pollution from human activities is cause of the extinction of many animal species, damage to trees and other plants, also rivers and lakes are extremely exposed to the problem as well as fish and others aquatic species. We must also consider the damage to buildings and wrecks, to statues and to all other constructions (EPA, 2007, p.1). Climate change has become the subject of several discussions and debates around the world. Newspapers headlines, TV talk-shows and politicians talk about it, movies and books have tried to give a representation of the issue. There have been numerous protest campaigns on the subject and yet many are still not clear on what they are actually talking about and the real reason that leads to climate change. In short, climate policies still create a lot of confusion in public opinion and there are still many gaps to correct. However, despite the various maneuvers adopted by governments around the world to reduce polluting emissions, pollution levels continue to grow and the quantities of CO_2 present in the air we breathe, reach ever higher numbers. Carbon dioxide represents most of the greenhouse gases present in the air and is produced mainly by the combustion of fossil fuel. According to the EPA (US Environmental Protection Agency) acid rain represents one of the main environmental problems due to smog produced largely by motor vehicles and in particular from the burning of fossil fuels. Acid rain is a phenomenon that affects the entire planet and the term (acid rain) refers to all the precipitations that contain different types of toxic acids. Acids are deposited on the soil both in wet and dry form, they can be contained in rain, snow, hail or even in fog. The acids contained in these precipitations are composed of sulfur dioxide (SO2) or nitrogen oxide (NOx) which in contact with water, oxygen and other chemical components trigger a reaction turning into sulfuric and nitric acids. Once these acids have settled on the soil, they can be carried by wind or air currents. This therefore makes acid rain a problem not only for those who live in areas where there is a high concentration of SO_2 and NOx but also for those who live in neighboring areas. Acidity and alkaline levels are measured on a scale with the use of PH as a unit of measurement. A level of 7.0 is considered neutral. The acids that settle on the soil become extremely harmful for vegetation, for animals and fish, for plants and trees as well as for people's health. However, aquatic ecosystems are those most affected by the issue of acid rain. Some species have greater tolerance, while others suffer more from the environment conditions. In particular, the younger generations of

each species suffer more than the adult ones. There are some acid lakes with no fish because the pH is extremely low and consequently the species do not survive. Often, even if a species has a higher tolerance in terms of PH, it can happen that the one they feed on are more sensitive and therefore does not survive in the same environment, thus leading to the extinction of even the most tolerant species. This creates the so-called ecosystem chain effect. Furthermore, areas where there are dead or dry plants and trees, are a clear sign that the area was particularly affected by acid rain. Acid rain deprives the soil of minerals, essential for the growth of plants and trees. Another relevant issue we should take into account is the global warming mostly due to greenhouse emissions. Greenhouse gasses are extremely harmful as they warm the Earth by absorbing energy and slowing down the escape of energy in space. In other words, without the greenhouse gases the planet would be immersed in ice. However, following the industrial revolution, which led to an increase in the combustion of fossil fuels, the amount of greenhouse gases in the atmosphere has soared, creating a significant increase in temperatures all over the world (EPA website)[14].

Chapter 2 Laws and regulations UE & USA

As mentioned in the previous chapter, pollution from the automotive sector causes, every year, an impressive amount of deaths and diseases, as well as a significant environmental impact. It is important to stress that the emissions legislation for light duty vehicles (LDV) is divided into two macro categories: Pollutant emissions and Greenhouse gas emissions. The first category concerns substances that are extremely harmful to human health and the surrounding environment (Ozone, NO_x and fine particles are part of this category). Air pollution standards are established and regulated by the World Health Organization (WHO). These standards are adopted by several regions worldwide. However, even today these standards exceed in many European cities. The greenhouse gas category basically concerns CO_2, but also CH_4 (Methane) and N_2O (Nitrous Oxide). These substances represent a significant problem for the world climate. Indeed, these emissions have greater impact globally than locally (Continental, 2019, p.17-20). When governments around the world became aware of the seriousness of the phenomenon, they began to adopt legislation and regulations to limit the damage as much as possible. The best way to reduce environmental pollution produced by road vehicles is to take measures that limit emissions from the beginning. In other words, it is necessary to impose on car manufacturers the adoption of

[14] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

systems and technologies aimed at reducing as much as possible the damage caused by the use of vehicles by road. Thanks to the intervention of governments and the laws imposed on car manufacturers and the circulation of vehicles, over the years, important objectives have been achieved in terms of reducing pollutants produced by car and trucks. By this way, all around the world, new institutions were born, with the responsibility for keeping the phenomenon under control through the establishment of regulations and standards as well as strict periodic checks. These limitations imposed by governments all around the world, have entailed considerable costs for manufacturers, taxpayers and car owners (B. T. H. E. I., p.3-4). However, despite the countless struggles against the pollution produced by road vehicles, the expectations on pollutant reductions are not yet fully satisfied and the phenomenon is still a current problem for the society. As the imposition of certain standards involve high initial costs, the allowed emission levels vary depending on the country or geographical area. However the main systems of regulation of vehicle emissions are those adopted by Europe and North America. In particular, the United States was the first to consider the problem of air pollution due to vehicular emissions and to set regulations for their reduction. Over the years, international emissions legislation has gradually evolved. Initially, attention was mainly focused on the visible smoke emitted by vehicles and then moved on carbon monoxide and later on oxides of nitrogen and hydrocarbons (Faiz A. Weaver C.S., Walsh, M.P., 1996, p. 2). The aim of this chapter is to illustrate the actual legislation concerning the vehicular emissions in Europe and U.S, in order to provide a better understanding for the next chapters. Moreover, some important concepts will be mentioned, such as the defeat devices that have had a marked role in the Dieselgate case, as well as some organizations that have taken part incisively in the WV scandal.

2.1 United States emission standards

Nowadays, it might seem senseless to think that before 1970 anyone could expel tons of toxic gases and harmful pollutants without caring about the damage and the danger these substances lead to society and the environment. All this was possible because before then no one had ever thought of imposing regulations or limitations to safeguard the health of people and the planet. No one before the EPA. In the United States of America, the standards for emissions from engines and cars are regulated by the EPA[15] (US Environmental Protection

[15] The organization was officially founded on December 2nd, 1970 with the aim of carrying out research, consolidating standards and monitoring polluting emissions, as well as ensuring protection against activities that

Agency). The California region, on the other hand, has a special status in terms of emissions regulation. This region has the power to impose lower and stricter standards than global standards. California enjoys this independence as the EPA has granted the freedom to manage standards to all those states that had adopted emissions prevention regulations before March 6, 1966. The authority that manages emissions in the state of California is the CARB (California Air Resource Board). The CARB as well as the EPA is responsible for detect and verify any violations of the standards imposed on emissions (Hui He, Lingzhi Jin, 2017, p.2). Over the years, numerous changes have been made to the standards for emission regulation in the United States. The increase in studies and research by the EPA and CARB has made it possible to obtain more and more evidence and awareness of the different pollutants produced by the use of motor vehicles and their impact, thus making it possible to take increasingly more concrete decisions regarding the problem. The EPA implements its regulations to limit emissions and air pollution in general, through the Clean Air Act[16] (CAA). This federal low contains all the environmental lows adopted by the United States for the preservation of air quality and to keep under control air pollution. The CAA allows the EPA to impose determinate emission standards for new vehicles[17] releasing a certificate of conformity. Each new vehicle without a certificate of conformity from EPA may not be sold in the United States of America (Hui He, Lingzhi Jin, 2017, p.4). With the inauguration of the new EPA, the Heart Day was also established, a world day for raising awareness for environmental protection. Nowadays, this day has been observed worldwide on April 22 of each year since 1970. Through decisive maneuvers, the EPA during its first 20 years of operation, reached unimaginable goals. More than 200,000 premature deaths have been avoided thanks to significant reductions in terms of pollutants extremely damaging for health, present in the air we breathe. On April 30th 1971 was published the first national regulation for the control of six categories of pollutants in the air in order to set the National Ambient Air Quality Standards (NAAQS). The six categories are respectively: particulate matter, photochemical oxidants, sulfur oxides, carbon monoxide, nitrogen oxide and hydrocarbons. However, the program referred just to light duty vehicles (LDV) without considering the category of heavy-

cause environmental pollution. One of the main events that led the initiative to create this organization was the Cuyahoga River fire which caused considerable damage related to water pollution (EPA, https://www.epa.gov/history).

[16] The Clean Air Act was established in 1970 but more revisions were implemented in 1977 and 1990.

[17] either they are produced inside or outside the United States

duty engines (HDE)[18]. At the begin these limitations were imposed just in a few cities with the aim to induce health protection. Everyone had a duty to commit to achieving the standards imposed by 1975 (EPA press release, 1971). However, considering the different characteristics and habits among the various states, lowering emissions to reach the standards required by law within the established deadlines was not an easy task. Many states had great difficulties and failed to comply with the terms imposed by the law, taking several years to reach the standards. Furthermore, in the same period, the EPA imposed labels on fuel consumption that were applied to the glass of all new light cars to make it easier for consumers to recognize the consumption of the new cars they would buy. Obviously, over the years the labels underwent numerous updates to make consumers more and more informed on fuel consumption but also to adapt to market changes and to achieve improvements in vehicle testing (EPA). On 4 March 1985, the new standards in the use of petrol were announced with the aim of bringing its consumption to a reduction of 90% starting from 1 January 1986. The objective was to reduce the lead content in the 1.10 grams per gallon gasoline at 0.10 grams per gallon. These standards stemmed from the idea that the lead contained in gasoline was one of the major pollutants harmful to the people's health. The EPA Administrator of that period, Lee M. Thomas, through this maneuver, also hoped for a cost reduction of $ 6 billion thanks to the reduction of emissions of gases expelled from vehicles, to the reduction of vehicle maintenance as well as reducing the costs for medical care of those who would be long term exposure to lead emissions (EPA, press release, 4 March 1985). Starting with the Clean Air Act, two Tier aimed at regulating the standard emissions for light vehicles were established. Both Tier 1 and Tier 2 were defined starting from 1990. In the late 1990s, the EPA, thanks to the help and research of some universities, developed a portable device to monitor emissions while driving a vehicle directly on the road. This device (called PEMS) allows to test the emissions produced under normal driving conditions, thus taking into consideration all external factors that could influence the results. Nowadays in the United States all light vehicles must meet certain standards in terms of emissions, to ensure that these standards are met, two specific tests have been designed (the FTP-75 city driving test and the HWFET highway driving test) which test vehicles in order to measure their emissions and fuel consumption. Any software, hardware or device installed on vehicle engines acted to inhibit or manipulate emissions, is strictly prohibited by law. These systems are called defeat devices

[18] The HDE emission standards were implemented for the first time in 1980 (Hui He, Lingzhi Jin, 2017, p.14).

and they are able to bypass formal emission tests. The construction and sale of defeat devices in the United States is regulated by section 203 of the CAA:

"The following acts and the causing thereof are prohibited [...] for any person to manufacture or sell, or offer to sell, or install, any part or component intended for use with, or as part of, any motor vehicle or motor vehicle engine, where a principal effect of the part or component is to bypass, defeat, or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this subchapter, and where the person knows or should know that such part or component is being offered for sale or installed for such use or put to such use; [...]"

Over the years there have been numerous cases of manipulation of emission controls. Equally numerous were the sanctions imposed by the EPA on car manufacturers that tried to game the system, with the consequent imposition of numerous emission recall[19] (M. Contag et al., 2017, p.26). Indeed, the Volkswagen case of 2015 wasn't the first attempt of the automaker to break the rules. On July 23, 1973 Volkswagen was accused by the EPA for selling vehicles with defeat-device systems in four of their models produced in the same year. The car manufacturer was then forced to pay a fine of $ 120,000 for violating the emission standard rules (Wall street journal, 1994). In 2000, the Tier 2 Gasoline Sulfur program marks an important turning point for the automotive industry. According with a recent report of Continental regarding emission standards worldwide (2019, p.107), this program focused mainly on the reduction of NOx emissions, a substance that is extremely dangerous and harmful to people's health. In fact, a drastic lowering of the NOx emission standards was imposed, which switched from 0.6 g / ml to 0.07 g / mi. These standards had to be met by all light duty vehicles[20], light trucks and medium-duty passenger vehicles[21] without distinction of fuel. The program was split into 8 bins. Instead, in 2009 the standard for NO_x emission was fixed to a maximum level of 44 mg/km (Smith & Parloff, 2016). After the clamorous scandal about the tampering of the 2.0 TDI engines of the VW with defeat device, started in 2015, in 2017 the new Tier 3 program is finalized. The program led to a further modification of the standards on vehicle emissions and a lowering of the sulfur contained in gasoline.

[19] An emission recall is a program acted to induce an automaker to enhance and make adjustments to an emissions-related problem. Those programs mean elevate costs and efforts for the manufacturers plus reputational damage. Emission recalls represent one of the most efficient tool against automaker emission violation

[20] In model year 2007

[21] In model year 2009

Furthermore, the program is strongly oriented towards the reduction of greenhouse gas (GHG) emissions from light vehicles starting from the 2017 models (Continental, 2019, p.109-110).

2.2 European regulation

The European Union started considering the regulation of air pollution produced by vehicle emissions since 1970, establishing and imposing limitations that were applied also to future member countries. The European Union legislation is based on a hierarchical pyramid scheme that envisages the United Nations Economic Commission for Europe at the top of the pyramid and subsequently are directly subordinated to the EU Regulations and EU directives. The regulations dictated by the United Nations Economic Commission for Europe (UNECE)[22] are at the top of the pyramid of the European Union legislation. Regarding the polluting emissions, the UNECE regulations set the limitations and standards to be adopted internationally while timings of introduction are always managed by EU regulations. UNECE regulations may be adopted by all member states that signed the 1958 UN agreement. Within the European Union, the adoption of UNECE amendments is published directly in the official gazette. All EU regulations (managed by the European Parliament and the EU Council of Brussels) are legislative acts that have binding effect for all member states which means that all states belonging to the Union are obliged to adopt the aforementioned regulations in its own internal legislative system. Finally, the EU directives are goals that every member state must achieve within its own territory. However, the methods of achieving these objectives are managed internally and independently by each state. EU directives must be introduced as a law in force by a specific deadline or replaced by existing laws (Continental, 2019, p.32).

The document that regulates the limits and standards on emissions in the EU is the framework Directive 2007/46/EC which will be subsequently replaced by the directive EU 2018/858, which will enter into force on 30 May 2020. Furthermore, the Treaty on the functioning of the European Union also includes a section dedicated to environmental pollution (Art. 190-193)[23]. These documents set up the regulations for the certification of approval of motor vehicles establishing the standards on polluting emissions. Furthermore, Directive 2007/46/EC also regulates the methods for performing tests carried out in the

[22] UNECE is one of five regional commissions of the United Nations

[23] Consolidated version of the treaty on the functioning of the european union (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=IT)

laboratory for emissions control. According to the European Whole Vehicle Type Approval System (WVTA) in order to obtain a certificate of conformity for a vehicle model, manufacturers must contact an organization authorized by the national authority which will make a laboratory test acted to control emission standards conformity. No other further tests are required. The type approval authority (TAA) verify that the type of vehicle being tested is compliant with the directives that define the respect to safety parameters and environmental requirements. Subsequently, the TAA will issue the manufacturer with the certificate of conformity (CoC) which certifies that the vehicle type complies with the EU type approval requirements. However, as we already know, laboratory tests never represent the actual emissions produced by a vehicle under normal driving conditions on the road. Until 2013 no significant changes were made for the type approval framework directive. However, the 2015 VW scandal alerted the authorities to the use of defeat devices, creating a high level of criticality for the type approval process (Continental, 2019, p.34). In Europe the defeat device is regulated by the art. 5 of regulation No. 715/2007 CE. Article 3 of regulation No. 715/2007 CE gives a precise definition of defeat device as follow:

"'defeat device' means any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use"

The use of defeat device is strictly prohibited, and clearly, their production as well as their installation provides penalties for anyone who violates the regulation. The regulation also governs a series of exceptions for which defeat devices can be tolerated and allowed under the law. These exceptions are regulated as follows by Article 5 (2):

(a) the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;

(b) the device does not function beyond the requirements of engine starting; or

(c) the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions.

These exceptions leave room for a personal interpretation that would allow the defeat device to be misused. Finally, on June 14th 2018 the new Type Approval regulation (EU) 2018/858 was published. The new regulation focus on greater homogenization of type approval legislation in all member states of the European Union. Furthermore, the European Commission reserves the right to audit the approval processes carried out by the national authorities in order to ensure that the regulations are strictly adopted and followed by all EU member states. Finally, the new regulation allows member states to challenge type approval certificates issued by other countries in the event of discrepancies (Continental, 2019, p.34-35). A study of the Joint Research Center (JRC) published in 2010, through the use of a portable device, detected a high concentration of NO_x produced by the diesel engines that exceeded exponentially from type approval values. Thanks to the introduction of the Commission Regulation (EU) 2018/1832 of 5 November 2018, the gap between the tests carried out in the laboratory and the road tests has been considerably limited, also limiting the risk of fraud. This regulation, in fact, through a procedure called Real Driving Emission (RDE)[24], subject's vehicles to a road homologation test under normal driving conditions[25] to verify their real emissions. In addition, this test includes a specific route to follow during the trip as well as a specific average speed to maintain depending on the road conditions (Continental, 2019, p.51). A further section of the Type Approval regulation which requires attention is reserved for the emissions of light duty vehicles. The limitations in terms of emissions are defined in Regulation (EC) No 715/2007. These limitations are divided for different type of pollutants, the type of vehicle and the powertrain (Continental, 2019, p.36). As well-known the main polluting emissions that need more attention are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxide (NOx), particulate (PM) and carbon dioxide (CO2). The standards for the regulation of polluting emissions produced by motor vehicles have been progressively changed in an increasingly rigorous way. These standards were cataloged under the name "EURO standard". On 26 June 1991, Directive 91/441 / EEC of the European Council introduced the first form of "EURO standards" in the European Union, or the Euro 1 standard. Council Regulation No. 715/2007 replaces and repeals the previous regulations thus introducing the new Euro 5 and Euro 6 standards[26]. The first restrictions on CO_2 emissions for new passenger cars were introduced by the Regulation (EC) 443/2009 of the European Parliament and the Council on April 23, 2009. The CO_2 target imposed for passenger cars is

[24] Regulation (EU) 2016/646
[25] Through using portable emission equipment
[26] The Euro 6 standard is define by Regulation 715/2007

set to 130 g / km[27] whereas for the new light commercial vehicle category the limit is 175 g / km[28] (Continental, 2019, p.37). Those standards will change starting with 2020 and the future limit will be 95 g / km[29]. On the other hand, NO_x emissions represent another problem widely discussed in the European Union as well as all over the world. The limits for NO_x and PN are defined by the so-called Not-to-Exceed (NTE) and each pollutant is defined separately by a conformity factor (Continental, 2019, p.78). The standards imposed for NO_x emissions in 2009 was 180 mg/km (Smith & Parloff, 2016). The main Euro 6 standards are illustrated in the following table 2.1:

Table 2.1 Actual Euro 6 limits for Gasoline &Diesel vehicles

Categories	Reference Mass (Kg)	CO (mg/km)		NO_x (mg/km)		PM (mg/km)	
		Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Passenger cars	All	1900	1750	90	140	12	12
	RM ≤1,305	1900	1750	90	140	12	12
Commercial vehicles	1,305<RM≤1,760	3400	2200	110	180	12	12
	1,760<RM	4300	2500	120	220	12	12

Source: Adapted from Continental Automotive (p.94), https://www.continental-automotive.com/getattachment/8f2dedad-b510-4672-a005-3156f77d1f85/EMISSIONBOOKLET_2019.pdf

Chapter 3 The Volkswagen Group and its emissions scandal "Dieselgate"

The term Dieselgate was born following the fraud of the Volkswagen group made known for the first time in 2015. The Volkswagen group is a multinational automobile manufacturer, headed by the German automaker Volkswagen Aktiengesellschaft (Volkswagen AG) based in Wolfsburg in Germany. The German automaker began its success in the sixties when the beetle achieved record sales. With global dominance in the United States, the beetle, originally ideated by Adolf Hitler, represented the people's car and the counterculture's one. Over the years, Volkswagen acquired several car manufacturers forging

[27] Regulation 443/2009
[28] Regulation 510/2011
[29] Future limits for passenger cars (reference mass ≤ 1.392,4 kg), for heavier vehicles the ratio is +3.3 g/km each 100kg.

a solid and extremely competitive automotive group worldwide. Nowadays, as we can read on the official website of the VW group, the multinational is composted by 12 brands from 7 European countries. With an average of 44.000 vehicles per day and a total annual production of 11.018.000 vehicles in 2018, VW is the undisputed European leader terms of sales and production. Notwithstanding, the violation of the standards imposed by the Clean Air Act (CAA) through the installation of manipulation systems, so-called defeat devices, on a series of diesel engine models cost the German automaker, image and a lot of money. The impeachments against the Volkswagen Group were multiple, including consumer fraud and false advertising (Smith & Parloff, 2016). According to a study conducted by Mauro Fracarolli Nunes and Camila Lee Park (2016), the Dieselgate case would have brought the VW a total loss of 6.44 billion dollars. However, following investigations and accusations against Volkswagen, it emerged that other manufacturers had also manipulated the diesel engine emissions of some models in order to meet the standards imposed by the law. Most consumers who bought one of the models with defeat devices returned the cars asking for a refund. Consumers in this case were exposed to a double risk. First, those who bought a car with a defeat device exceeded the diesel emission standards, which meant restrictions on traffic in urban centers. On the other hand, as consumers fear change in diesel car policies, there was a financial disadvantage as the residual value of the vehicles would have fallen dramatically and the price of diesel cars dropped. Nowadays, in an evolved world like the one we lived in, every company has the obligation to consider much more than the profits and losses from the activity of the business. Over time, several experts and economists have presented different ideas on the importance of shareholders. However, there is a group of subjects who, although even not directly involved in the company's activities, can be indirectly affected by the effects that the activities of companies cause on the external environment. The moral and ethical duty towards people and the external environment represent for businesses a cost in terms of time and money. Volkswagen, using the software installed on the diesel engines of its cars, aspired to achieve success in the shortest time, willing to do anything to achieve their goals. The society was pervaded by a sense of generalized indifference that led employees and managers to act without considering the damage caused by their actions.

3.1 History of the international automaker

The automotive group with international renown that we know today as the Volkswagen Group has acquired over the years 12 automotive brands headed by the German company Volkswagen Aktiengesellschaft (Volkswagen AG). The Volkswagen AG was founded in 1937 in Wolfsburg (German state of Lower Saxony) under the control and orders of Adolf Hitler. Wolfsburg did not exist as a city before the arrival of the VW factory and all that today is in the city was born thanks to the factory. It is a gigantic-sized factory, it represents the largest plant in the world and the largest carmaker in Europe. In order to meet the middle-class desire to own a car, the Führer, for propaganda purposes, wanted to reproduce the same idea of car produced by Henry Ford in America (Rieger, B., 2013, p.45). In the 1930s, owning a car in Germany was a luxury that not everyone could afford, the average of car ownership in Germany was around one car every 242 inhabitants[30]. Meanwhile, in the United States, Ford built a car for everyone that allowed many more middle-class people to own a motor vehicle. In fact, in 1927 some American statistics claimed that in the United States the rate of owning a car was around one automobile per 5,3 inhabitants, making US by far the most motorized state worldwide. The American automotive market represented at least 80 percent of the overall amount of the world's car. The difference between Germany and the United States in terms of automotive market was enormous and German people would never imagine the realization of a "people's car" in their country (Rieger, B., 2013, p.11-13). According to Rieger, B (2013, p.26) Hitler as well as many other European people, marveled and aspired at Henry Ford's success. The reading of Ford's biography translated into German "My life my work"[31] was an important source of inspiration for the realization of Hitler's automobile projects. Ford Motor Company represented the first automaker giant in the American business scene at the begin of the nineteenth century when the legendary Model T[32] was launched. Model T was the result of the ambition of Henry ford to design and provide an automobile able to meet the needs of the masses, citing his words, a "universal car". There is no doubt that Model T was the most practical and affordable automobile ever but unfortunately not the most comfortable one (Rieger, B., 2013, p.15-16). Starting from 1933, Hitler begun sustaining and financing several projects for the improvement and development of the automobile era. Thus it was that Hitler commissioned

[30] The average turns out into one vehicle every 196 habitants if we consider also buses and trucks.
[31] The book is an autobiography and an outline about the work done by Henry Ford in its factory based in Highland Park, Michigan. The German translation of the book became a best seller in Weimar, Germany, selling more than two hundred thousand copies in less than two years.
[32] The original Model T was powered by a four-cylinder engine with twenty- horsepower.

the Austrian engineer Ferdinand Porsche to design the so-called “people's car”, subsidizing the project with funds from the Nazis. In fact, the term “Volkswagen” in German means “people’s car”. Porsche boasted a noticeable career in the automotive sector working as engineering director of the Daimler-Benz, Mercedes. Hitler's goal was to open the world's largest factory, keeping the American Ford as its model of inspiration and Ferdinand Porsche represented the ideal person to realize his project (Rieger, B., 2013, p.61). The Führer asked Porsche to design the cheaper and affordable car ever seen until then with a target price of no more than 1.000 Reichsmarks. This strict parameter began to be a big obstacle, making the work for the project more and more complex and slow. Nevertheless, this hasn't discouraged Hitler’s favorite engineer, whom powered by the ambition of becoming the Germany’s Henry Ford, kept going on with the studies for the realization of the “people’s car”. Driven by a technical aspiration, Porsche started a workshop in Stuttgart with some other specialist for the realization of a vehicle prototype. They worked over all the technical aspects as well as the shape of the car’s body. The engineers opted for a four-cylinder engine while an air-cooled design was adopted in order to make the vehicle lighter and improve its fuel efficiency employing around 7 liters every 100 kilometers. In May 1938 the Third Reich’s leadership ordered the beginning of the works to erect the factory that would host the realization of the future of mass motorization in Germany (Rieger, B., 2013, p.66-71). Unfortunately, as Rieger claims in his book, at the end of the Second World War, the factory was completely destroyed but the dream of Hitler was deeply supported by the Beetle’s engineer and with the aid of the British army they recovery the Volkswagen factory and initiate the production of the famous vehicle (2013, p.97). In fact, it was only after the downfall of National Socialism that the Austrian engineer finally realized Hitler’s[33] idea by building the famous "beetle". Before starting the realization of a mass production chain of its prototype, Porsche went to Detroit with the aim to visit Ford’s factory at River Rouge. Following the Second World War, Ivan Hirst[34] and Ferdinand Anton Porsche (son of Ferdinand Porsche) resumed the reins of the business based in Wolfsburg in Germany. With the start of its production after 1945, the beetle became an international best seller and consumers bypassed the Nazi origins behind the car concept. At the very beginning of 1948, Heinz Nordhoff was in charge of conducting business and taking the place of Managing Director (Rieger, B., 2013, p.110). In the middle of 1955, the German automaker headquartered in Wolfsburg celebrates one million cars

[33] The Third Reich died before the realization of the project.
[34] He was a British officer

produced, an excellent and unexpected result (Rieger, B., 2013, p.123). In fact, after the second-world-war, the Beetle played a fundamental role throughout Western Europe, representing a protagonist in the era of motorization as well as the leading small car in the United States. Instead, in Germany, at the beginning of 1960s one car out of three was a Beetle. Today the original beetle is an international icon for the automotive world and over the years the admiration for this model has fueled consumer demand for the new beetle models. Nowadays, owning an original beetle represents much more than a mobility solution, it is a status. The legendary small beetle model designed by Ferdinand Porsche was the first car to outsell the famous Model T created by Henry Ford between 1908 and 1927. This new model was very close to the first one and there were several mechanical and technical similarities. However, unlike Ford's T model, which remained at a limited market in the United States, the VW Beetle expanded internationally, maintaining a growing level of sales from the beginning of its production after the second world war until the end of the 1900s. Henry Ford reached a global sales record produced over 15 million Model T in the period between 1908 and 1927. Nobody could have imagined that this record would be overpassed by the Volkswagen Beetle in 1972 (Rieger, B., 2013, p.17). Consumers looking for good deals were impressed by the high quality of the products employed for the production of the Beetle and in a particular way from the high level of the technical characteristics of the vehicle that made it unique in its kind. Moreover, the distinctive shape and design of the Beetle made this model the icon of the VW, creating an indelible mark on the minds of consumers. Production and sales continued to grow rapidly and continuously for more than fifteen years and nearly 40 percent of the VW cars were distributed in the US market. Unfortunately, in 1966 the company began to face the first problems, a slump in domestic sales was the consequence of a 2.1% GDP decline. In 1967 the amount of sales in Germany dropped from 600,000 to 370,000 in less than two years. This sharp contraction in sales was associated with a period of strong economic and political crisis in the country that fears consumers who postponed the change of the old car to a new one. Following the drastic collapse in sales, to recover, VW absolutely had to offer consumers a new product, with a more attractive design, greater comfort and greater performance, while maintaining a competitive price. In 1968, in succession to Heinrich Nordhoff[35], the reins of the VW passed to Kurt Lotz. The new CEO brings numerous changes to the German company such as business management improvements, implementation of electronic data processing, more

[35] The ex CEO who led VW after the II World War, left the company because of a stroke in spring 1968.

investment in research and development. However, Lotz resigned in 1971 and was replaced by Rudolf Leiding. Due to various external and environmental factors including a resounding increase in oil in the United States and a drastic increase in inflation in West Germany, the German carmaker's business went from bad to worse. In 1975 has been created a holding company, under the name Volkswagen Group, with the aim to take care of the entire operations. In the same year, following a long period of proliferation and well-being, West Germany registered the overcoming of one million unemployed. In this period of uncertainty and global instability, Leiding's ability to control costs turned out extremely useful for VW. The new CEO made a reversal of the development program erected by his predecessor and proposed the inclusion in the company's catalog of four new models. Thanks to Leiding's initiative, Volkswagen gradually launched three new models between 1973 and 1975: Passat, Golf, and Polo. Leiding resigns as Chief of Volkswagen at the end of 1974. In February 1975 Toni Schmücker, with a brilliant career start at Ford and then in Rheinstahl, becomes the fourth VW chairman. Schmücker wanted to make a substantial cut in the workforce with the aim of laying off 25,000 workers in West Germany (Rieger, B., 2013, p.243-248). The unexpected initiative of the new CEO raised many criticisms from public opinion. Numerous newspapers and critics discussed and questioned about the severe crisis the German automotive giant was facing. However, the Schmücker's maneuver proved to be extremely effective and to the great surprise the new CEO managed the situation in an excellent way, exceeding the budgets predefined by the new program. The company offers very advantageous severance packages to all those who have agreed to resign voluntarily from the automotive group. This clever move by Schmücker made the transition of organizational change much easier to manage, considerably limiting the complaints of workers. Between April and July of 1975, 32,000 workers voluntarily resigned from the VW group. From then on, with the production of the new Volkswagen Golf launched in 1974, the automotive group resumed prospering for several years, recording sales volumes that no one could ever have imagined. With the high demand of the new Golfs, the sales of the original Beetle collapsed dramatically. Following the drop of sales, in 1978 the company stopped the production of the original VW vehicle in the Federal Republic (Rieger, B., 2013, p.251). In 1993 the Austrian engineer, Ferdinand Karl Piëch (nephew of Ferdinand Porsche) became the new chairman of the executive board at Volkswagen AG until 2002. With a brilliant career in the automotive market, he started at Porsche in 1963 and then moved to Audi in 1972, the Austrian engineer represented for the Volkswagen group a safety net. In fact, before the arrival of Ferdinand

Piëch, the Volkswagen group was going through a period of deep crisis and was almost close to bankruptcy. Sales of the company had dropped dramatically, and the production chain was extremely inefficient: the vehicles spend increasingly more time in the factory workshops with the consequence of elevated costs for the company. Piëch was a very smart person, extremely determinate and full of motivation. Thanks to his outstanding problem-solving skills, the Austrian engineer radically revolutionized the automotive group by setting high-level goals. Piëch invented the TDI (Turbocharged direct injection) and Volkswagen began producing vehicles equipped with Diesel engines. The TDI were a great success and their spread in Europe grew rapidly. Volkswagen defined the new TDI engines as the "clean diesel" that was set on cheap and fun to drive cars. From 2002 until 2007 Bernd Pischetsrieder, former CEO of BMW, leaded the company as CEO and chairman of the VW group. In 2007 Martin Winterkorn succeeded Pischetsrieder becoming CEO of the Volkswagen group until 2015, immediately after the big scandal of emissions (Independent News & Media, 2019). Subsequently, in 2015, after the vehicle emission scandal, Matthias Müller took Winterkorn's place and on 12 April 2018 he was replaced by the Austrian of German origin Herbert Diess. Before becoming CEO of the Volkswagen group, Herbert Diess was head of the BMW brand. Diess is particularly known for adopting cost-cutting measures thanks to the compromise reached with the unions. Moreover, his curriculum and his previous career in BMW seem to be excellent from all points of view. Diess became part of the VW group two months before the outbreak of the Dieselgate scandal and its commitment from the beginning was to reduce costs, especially considering the huge losses due to emissions fraud. The agreement reached with the unions has led to a cut of 30,000 jobs that saved the VW Group as much as 3.7 billion euros. CNN Business in one of its articles called Diess "The cost killer" but this fame Diess already had when he worked for the luxurious BMW brand where he spent almost two decades. The Austrian is actively engaged and motivated in re-establishing the VW group that has lost a lot of confidence following the Dieselgate case and its objectives are therefore aimed at reducing emissions and maximizing profitability. His intent is to completely reorganize the organization through targeted actions aimed at bringing the group to a radical change. In addition, he stated in a conference that he is particularly open to new partnerships that support his goals for the future (KC Crain, J.,Stein, & Vellequette, Automotive News, 2018).

3.2 Volkswagen group

The Volkswagen Group is one of the largest automotive manufacturers in the world and the largest automotive manufacturing plant in Europe. Nowadays, the Volkswagen Group, headquartered in Wolfsburg in Lower Saxony, has a portfolio of twelve automotive brands from seven European countries: Volkswagen Passenger cars, Volkswagen Commercial vehicles, SEAT, SKODA, Audi, Bentley, Lamborghini, Bugatti, Ducati, Porsche, Scania and MAN. Audi[36] was the first brand to be acquired by Volkswagen in 1965 which at the time was already an established carmaker of high-end cars (Rieger, B., 2013, p.238). In the fiscal year 2018, Audi recorded an operating income before special items of 4.7 billion euros. Furthermore, Audi owns entirely two brands of Italian origins: Lamborghini, acquired in 1998 and Ducati, acquired in 2012. Lamborghini[37], the most famous sports car manufacturer in the world, last year sold a total of 6,333 vehicles. On the other hand, Ducati[38], the only motorcycle manufacturer of the VW group, produces the top of its two-wheeled vehicles at its factory located in Bologna, Italy. In 2018, Ducati produced 53,320 motorcycles. More than twenty years after its first acquisition, the multinational company welcomes the Spanish automotive brand SEAT[39] in 1986. Nowadays, with 60 years of productivity behind it, SEAT develops and manufactures cars and components in its production factories in Barcelona and El Prat. In 2018, SEAT increased its sales revenue by 3.1% compared to the previous year, setting a new record for a total of 10.2 billion euros of revenue. The Czech brand SKODA joined the automotive group in 1991 and became fully owned by Volkswagen in 2000. Founded in the Czech Republic in 1895, SKODA has now 35,033 employees in its working team. The Group continues its expansion by welcoming the luxury car manufacturer brand Bentley Motors[40], founded in the United Kingdom and acquired by the VW company in 1998. The luxury car brand becomes exclusive to Volkswagen only since 2003. Bentley celebrated 100 years, since its foundation in 1919, on 10 July 2019 (bentleymotors.com). As can be read

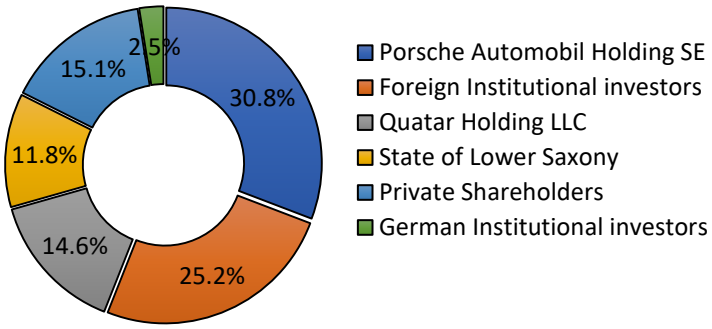
[36] Audi was established in 1909 and to date, it has 91.333 employees. Originally the brand name was August Horch Automobilwerke GmbH.
[37] The Italian automotive brand was born in 1963. Nowadays, it operates in its headquarters located in Santa Agata Bolognese, Italy. To date, the carmaker counts 1.777 employees.
[38] It was founded in 1926. Its production chain is composed of 1.591 employees. The brand is famous for its reputation in racetrack.
[39] The Spanish automaker brand start up in 1950. Nowadays, it has a total amount of 15.558 employees working on the SEAT production chain.
[40] Actually based in Crewe (UK), the luxury car brand was originally born as an independent business and in 1931 it was acquired by its historic enemy Rolls Royce. In 1998 the brand becomes part of the Volkswagen Group and BMW (which already held shares of the brand). It was just in 2003 that Bentley becomes completely owned by the VW group.

from the 2018 annual report of the VW group, the number of cars sold by the British giant in 2018 is slightly down compared to 2017, for a total of 10.5 thousand vehicles sold compared to 11 thousand in the previous year. The 1998 represents the year of luxury partnerships for the automotive group. In fact, in addition to the acquisition of Bentley, Lamborghini and Rolls Royce (sold to BMW in 2003), in the same year, Bugatti became part of the multinational company. Nowadays, with a history of more than a hundred years, Bugatti[41], the world-famous car brand originally founded in France, builds the most luxurious, powerful and exclusive super sports cars in the world. On the other hand, in addition to passenger cars, the Volkswagen group treats also commercial vehicles, trucks and busses. The first brand of commercial vehicles of the VW group, was born in 1995 and it operates in total autonomy as a legal entity under the name Volkswagen Commercial Vehicles. VW commercial vehicles has its headquarter in Hanover (Germany) and actually the brand manages 24.783 employees. As it can be read on the VW annual report 2018, in the previous fiscal year (2018) the brand of commercial vehicles sold vehicles for a total sales revenue of €12 billion (p.36). Scania Vehicles and Services, MAN Commercial Vehicles and Volkswagen Commercial Vehicles make up the "Commercial Vehicles Business Area" of the Automotive Division of the VW group. MAN and Scania join the multinational company respectively in 2012 and 2008. As indicated in the Volkswagen AG annual report 2018 (p.117), the Commercial Vehicles Area, in 2018 reached a sales revenue of €36.7 billion and an operating profit of €2 billion (up €0.1 billion compared to the previous year). Finally to join the VW group is the German carmaker Porsche[42]. In fact, although Porsche has always had a close contact since the beginning with the Volkswagen brand, it is just in 2012 that the Porsche brand becomes wholly owned by the Volkswagen Group. In 2018 it reported an increase in sport car deliveries of 4.0% for a total amount of 256 thousand cars delivered. In terms of revenue, Porsche's sales rose reaching an impressive sales revenue of €23.7 billion[43].

[41] This brand represents a myth in the automotive sector especially for its remarkable design.
[42] The luxury car brand was born in 1931 and to date it has its headquarter in Zuffenhausen, Stuttgart (Germany).
[43] In 2018 Porsche Automotive reached an increase in sales revenue by 9.2% compared to the fiscal year 2017.

ructure"

Figure 3.1 Volkswagen Group Shareholders structure



As shown in figure 3.1, the automotive group is divided among five major holders and a minority one represented by the German institutional investors (2.5%). Porsche Automobile Holding SE represents the largest shareholder in the automobile group with 31% of the subscribed capital. Afterward, a 25% of the company is owned by foreign institutional investors, 15% belongs to private shareholders, 15% is of Quatar Holding LLC and 12% is owned by the State of Lower Saxony. However, the voting rights are distributed quite differently from the ownership interests. Indeed, voting right are respectively distributed to Porsche Automobil Holding SE, Stuttgart 52.2%, State of Lower Saxony, Hanover 20%, Qatar Holding 17% and in the end a 10% of the vote rights are owned by others individuals (Volkswagen.com, Shareholders Structure)[44]. Each brand has its own characteristics and operates independently on the market. However, despite the autonomy and independence of each individual brand, the management decisions of each company are made based on the interests shared by the group and the company itself. In fact, in addition to the individual administration system of each company, there is also an administration system of the group that supervises and guarantees the protection of the decisions taken by each individual brand in compliance with the laws. The administration system of the group in composed by the Management board and the Supervisory board (Volkswagenag.com).

The multinational company is divided into two macro-groups, one reserved for automotive production and engines and one dedicated to financial services. Starting from the design, manufacture, marketing and then sales, the automotive division takes care of the entire realization of each vehicle and engine produced by the VW group. As it can be read on the official website of the Volkswagen Group, the automotive division is divided into three segments which are respectively:

[44] https://www.volkswagenag.com/en/InvestorRelations/shares/shareholder-structure.html

1. "Passenger cars business area" which groups together the production of light vehicles of all the brands of the group such as motorcycles[45], small cars and luxury cars;

2. "Commercial vehicles business area" which covers all light commercial vehicles, trucks and buses;

3. "Power engineering business area" is a segment managed just by MAN Power Engineering that deals with the production of large-bore diesel engines for maritime transport, turbo-machinery, turbines, compressors and special gear units.

Table 3.1 Volume and financial data results by brand and field (fiscal year 2018)

Thousand vehicles/euro million	**Vehicle Sales**	**Sales Revenue**	**Operating Result**
Volkswagen Passengers Cars	3.715	€ 84.585	€ 3.239
Audi	1.467	€ 59.248	€ 4.705
SKODA	957	€ 17.293	€ 1.377
SEAT	608	€ 10.202	€ 254
Bentley	10	€ - 1.548	€ 288
Porsche Automotive	253	€ 23.668	€ 4.110
VW Commercial Vehicles	469	€ 11.875	€ 780
Scania	97	€ 13.360	€ 1.346
MAN Commercial Vehicles	137	€ 12.104	€ 332
MAN Power Engineering	-	€ 3.608	€ 193
VW China	4.101	-	-
Other	- 912	€ - 34.408	€ - 1.557
Financial Service Division	-	€ 32.764	€ 2.612
Volkswagen Group	**10.900**	**€ 235.849**	**€ 17.104**
Automotive Division	10.902	€ 201.067	€ 11.127

Source: Adapted from VW annual report 2018 (p.23), https://www.volkswagenag.com/presence/investorrelation/publications/annual-reports/2019/volkswagen/en/Y_2018_e.pdf

Furthermore, beyond the production of road vehicles, the VW group has a division dedicated to financial services including leasing, dealer and customer financing, fleet management, banking and insurance activities (VW AG, Annual report 2018, p.21). As can be

[45] Ducati is the only brand of the group producing motorcycles.

read on the official website "Volkswagenag.com", the multinational automotive company owns 122 production facilities worldwide of which the majority in Europe. Within the VW business, 664,496 workers operate covering the various positions of the automotive production chain all around the world. Sales of the VW group take place in 153 countries of the globe.

At the end of 2018, the multinational's catalog registered 365 different vehicle models and an average of 44,000 vehicles produced every day in the factories around the world. In terms of returns, table 4.1 below summarizes the group's financial and volume data reached in the fiscal year 2018 (VW AG, Annual report 2018, p.23). In the fiscal year 2018, the multinational has recorded surprising record results both in terms of sales and profits. In fact, as exposed in the 2018 annual report, the year-end operating income of the entire automotive group (before special items) amounted to 17.1 billion euros and a total of 10.9 million vehicles sold (Table 3.1). Volkswagen Passengers Group, with a total of 3.7 million vehicles sold and € 3.2 billion operating profit before special items in the year 2018, undoubtedly represents the brand with the largest production and sale of vehicles of the entire automotive group. However, being luxury cars, the Porsche Automotive brand is the one that in proportion to the vehicles sold generates the largest operating profit before special items for a total amount of € 4.1 billion.

Table 3.2 Volume and financial data results by market (fiscal year 2018)

Thousand Vehicles/euro million	**Vehicle Sales**	**%**	**Sales Revenue**	**%**
Europe and other markets	4.739	43%	143.089 €	61%
North America	925	8%	37.656 €	16%
South America	596	5%	10.405 €	4%
Asia-Pacific	4.640	43%	43.166 €	18%

Source: Adapted from VW annual report 2018 (p.23), https://www.volkswagenag.com/presence/investorrelation/publications/annual-reports/2019/volkswagen/en/Y_2018_e.pdf

From a geographical point of view, Europe/other markets represents for the automotive group the largest sales market, realizing in fiscal 2018 an amount of 143.1 billion in sales revenue and a total of 4.7 million vehicles sold (table 3.2). On the other hand, South America is the smaller market both in terms of vehicles sold and sales revenue (VW AG,

annual report 2018). In 2018 the group led by Volkswagen AG, won the seventh[46] place in the famous "Fortune Global 500"[47] list published annually by Fortune magazine.

3.3 The biggest automotive scandal

As mentioned above, the growth and constant evolution of globalization has led over the years to a significant increase in automobility and accordingly to an increase in polluting emissions produced by motor vehicles. In order to limit environmental damage and to reduce the impact on people's health, governments adopted increasingly stringent emission standards over the years, imposing on car manufacturers limitations in terms of emissions for new vehicles introduced on the market. These standards require companies to adopt costly innovative technologies as well as uncertain investments in research and development[48]. In the United States the diesel car market has never been very successful as the standards for emissions from diesel engines imposed by American law have always been much more restrictive than those imposed in European countries. In fact, in 2009 the maximum limit imposed for NO_x in America was 44mg NO_x/km, while in Europe the limit imposed was 180 mg NO_x/km (Smith & Parloff, 2016). Compared to gasoline engines, Diesel engines produce less carbon dioxide (CO_2) but in return it releases huge amounts of particulate matter (PM) and nitrogen monoxide (NO_x). High quantities of PM and NO_x in the atmosphere cause air pollution, cardiovascular problems and diseases of the respiratory system. However, to maintain the efficiency of Diesel engines and limit NOx emissions, car manufacturers over the years installed filters to burn pollutants before they came out of the exhaust. On the other hand, these filters are very expensive and to meet the standards imposed by US laws they need to be replaced very often. Conditions imposed by law create great difficulties for companies that are struggling to control production costs, as well as making competition between carmakers increasingly fierce. Therefore, whoever succeeds in meeting the standards by using the least number of resources and then offering a product at the best price on the market, "wins". As a result, companies are constantly overstressed and sometimes this become difficult to manage, sometimes leading producers to act wrongly and immoral. Over the years there have been several cases of automotive frauds, but Volkswagen's has been defined without doubt the largest automotive fraud ever. The term Dieselgate was born when

[46] The automotive group lost a position compared to the year 2017 in which it ranked sixth.
[47] The list ranks every year the 500 best corporations worldwide based on total revenue.
[48] Since research and development investments doesn't guarantee any success or failure, the investment made in R&D is not directly proportionate to the performance that will be obtained.

the Volkswagen Group was impeached of falsifying the emissions produced by a series of diesel engines produced by the company aimed to evade the laws. The vehicles indicted to have diesel engines manipulated by special devices, were sold on the US and European markets between 2009 and 2015.

3.3.1 What is a defeat device and how the Volkswagen Group used it

Since 2005, the biggest German automaker, led at that time by the CEO Ferdinand Piëch, wanted to build an image of the brand which reflects the environmental and ecological sustainability of its vehicles. According to Timothy W. Aurand et al. (2018), an advertising campaign promoted by the company in 2005 cited as follow

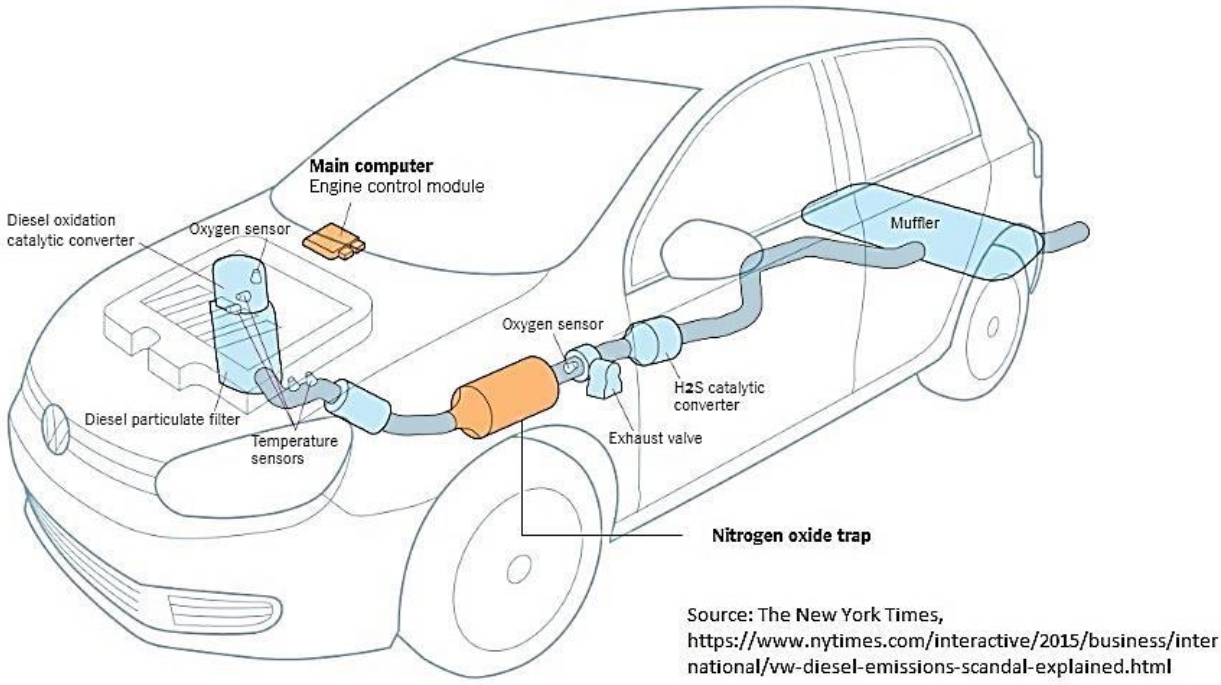
"Those who drive cars carry great responsibility but those that make them even more so".

In 2009 the Green Car Journal publishes an article drawing up a list of eco-carmakers and the Volkswagen, thanks to its 2009 Volkswagen Jetta TDI, was ranked first place as Ecological Car of the Year in America. However, this record turned out to be a great mistake because the Jetta TDI, as well as several other models of the Volkswagen group marketed between 2008 and 2015, were not equipped with the so-called clean-diesel engines as indicated in their technical sheets. It revealed to be a stratospheric hoax (Smith & Parloff, 2016). Volkswagen absolutely wanted to conquer the US market by offering diesel-powered cars but considering the strict rules and diesel technologies of that time, it wasn't that simple. Martin Winterkorn replaced Piëch and a new business strategy was introduced under the name "Strategy 2018". To achieve their goal and push Diesel into the American market, VW opened a new ecological plant in Chattanooga, Tennessee. The opening of the new factory represented for Martin Winterkorn an opportunity to highlight, in some conferences, Volkswagen's commitment to social responsibility through the production of eco-friendly and customer-oriented cars. In order to meet the stringent standards imposed by the US vehicle emission law, VW introduced a new clean diesel engine under the name “TDI” (turbocharged direct injection). The new TDI line represented an extremely innovative and advantageous offer for consumers. Apparently, it seemed that Volkswagen had found the solution to produce cheap cars with clean diesel engines that matches both the consumers' needs and the standards imposed by US legislation. In fact, the new Volkswagen TDI were apparently cheap cars, fuel-efficient, produced low polluting emissions and guaranteed excellent driving performance. The obsession to become the first manufacturer worldwide led to strong

psychological pressure within the company. This constant internal pressure led the employees to do everything just to increase sales of the automotive company.

On September 18, 2015, the EPA (Environment Protection Agency) officially announces that the German car manufacturer Volkswagen was indicted for selling vehicles equipped with defeat device systems aimed to cheat the results during laboratory emissions testing for homologation and bypassing the standards imposed by law. The Environmental Protection Agency described the Notice of Violation (NOV) in a press release and published all the details regarding the violation 2.0 Liter[49] on its official website (John C. Cruden, Bethany Engel, 2018, p.47). The EPA found out that the TDI vehicles sold by Volkswagen as clean diesel engines, exceeded forty times the limits allowed by the vehicle emissions law. It was clear that the automaker was using defeat device systems on their TDI vehicles sold in US.

Figure 3.2 Defeat device on motor vehicles

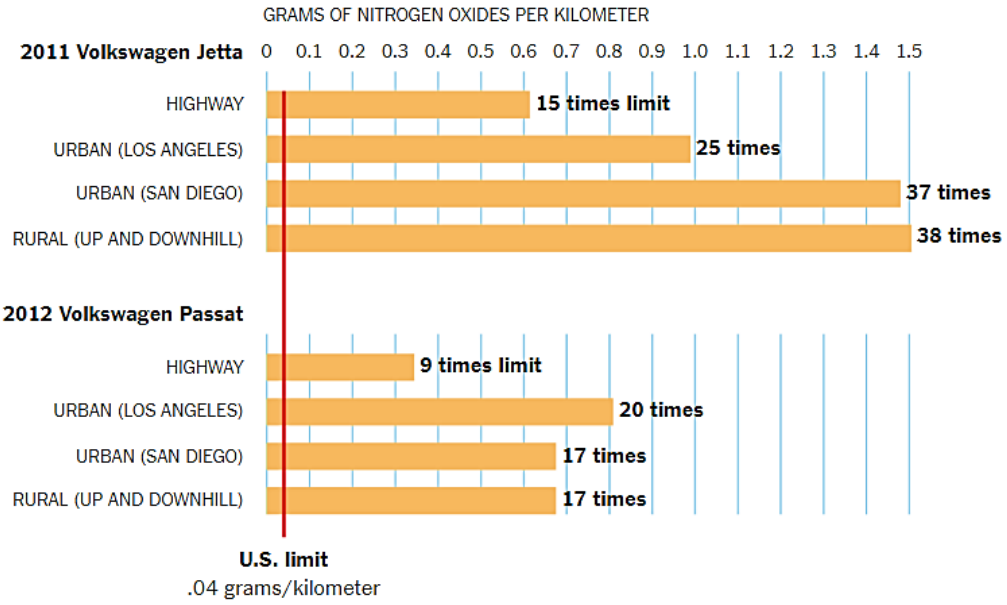


[49] 2.0 liter diesel vehicles model with defeat device where: Jetta (2009 – 2015), Jetta Sportwagen (2009 - 2014), Beetle (2013 – 2015), Beetle Convertible (2013 - 2015), Audi A3 (2010 – 2015), Golf (2010 – 2015), Golf Sportwagen (2015), Passat (2012 - 2015)

Defeat device systems are installed on motor vehicles with the purpose of bypassing emissions tests. It is basically a software capable of recognizing when the vehicle is tested for emissions standards, and it adapt engine's pollutants, but during normal driving conditions, the software turned the equipment down creating a different reaction in order to improve vehicle performance or save fuel. The software is installed to modify some components such as valves used to recycle exhaust gasses or catalytic converters. This software is activated automatically when it receives the test for the assessment of compliance with standards, offering answers in line with the limits imposed for pollutant emissions (M. Contag et al., 2017, p.5). Nitrogen oxide trap allows reducing the toxic emissions produced by the vehicle but to do so it must use much more fuel to capture nitrogen oxides. The software installed on the vehicle can allow the pass of a greater quantity of pollutants in order to limit fuel consumption (figure 3.2). The first tests to verify the real emissions of Volkswagen's TDI diesel cars sold in the United States were conducted by a group of researchers of West Virginia University in 2013 and then by the CARB (California Air Resources Board) in May 2014[50] (Gates, D., Ewing, J., Russel, K., & Watkins, D., 2016). They tested the cars first in laboratory and then on the road under normal driving conditions[51]. The tests realized in laboratory use rollers on which the vehicle is positioned simulating a driving session for data collection used to verify the emissions produced by the vehicle. These tests are practical because they allow test repetitiveness and save time and resources. However, it is an artificial approach that does not exactly reflect reality. Road tests, instead, were done with the use of a portable real-time emission measurement system like remote sensing and PEMS (portable emissions measurement systems). In the Volkswagen case, data were collected with a PEMS device. It is a small device that can be placed inside the vehicle, it is connected to the exhaust pipe and measures both the exhaust gas flow (ie the amount of gas emitted by the vehicle) and the components of the emanated gases. To obtain the total amount of the pollutants emitted by the vehicle should multiply the flow rate for the concentration. The results of tests carried out in the laboratory were compared with the results of tests realized on the road. Usually the tests carried out under normal driving conditions never reflect those carried out in the laboratory as the results are influenced by a series of variables such as outside temperature, traffic, slope and road wear. However, there is an acceptable level of deviation between the two tests, a deviation of five or six times is normal (ICCT, 2014, p.4-6).

[50] The CARB had commissioned the ICCT for the investigation of VW's vehicle emissions.
[51] Normally, tests are made in laboratory equipped with chassis dynamometer.

Figure 3.3 Average of NOx in VW's diesel vehicles during on road-testing

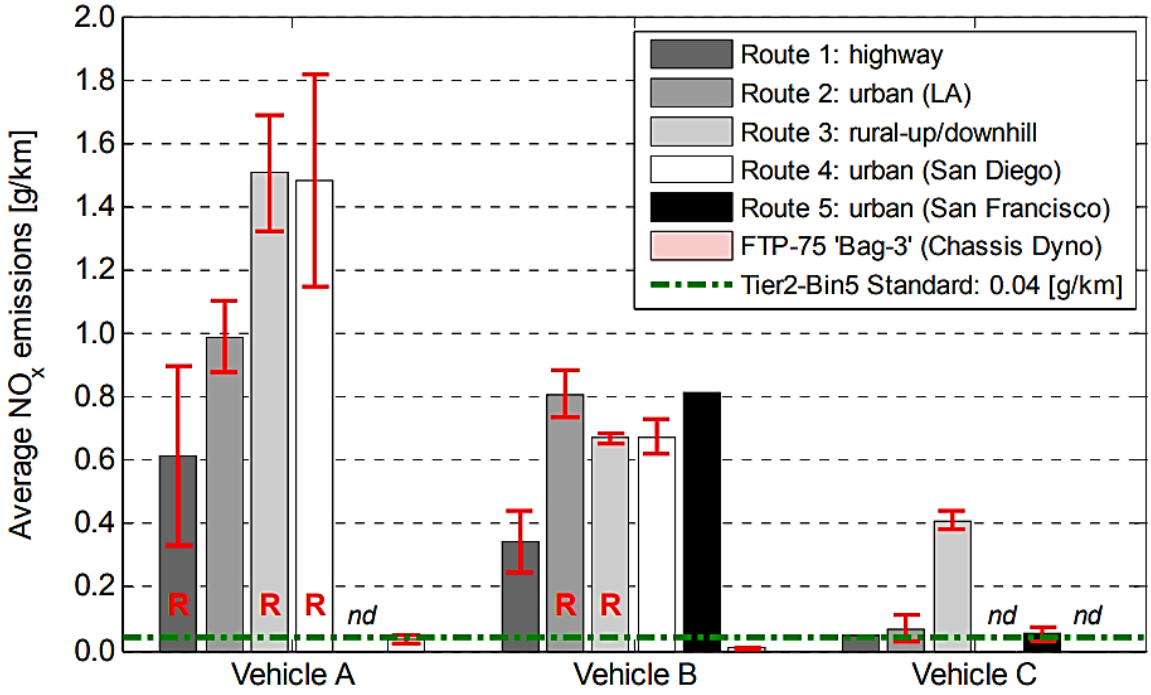


Source: West Virginia Report 2014, In-Use Emissions Testing of Light-Duty Diesel Vehicles in the United States, https://theicct.org/sites/default/files/publications/WVU_LDDV_in-use_ICCT_Report_Final_may2014.pdf

The study conducted by West Virginia University has examined three different light-duty diesel vehicles. At the end of the experimentation, they figure out that NOx deviation levels of both Volkswagen TDI cars using 2.0 liter engines, were forty times higher than the official Volkswagen data (figure 3.3). In 2014, during an academic conference held in San Diego, California, John German, senior fellow at the ICCT, exposed the study carried out by the University of West Virginia. However, as illustrated in figure 3.3, the three vehicles examined by the report were kept anonymous by cataloging them as Vehicle A (2012 VW Jetta), Vehicle B (2013 VW Passat) and Vehicle C (BMW X5). At the conference there were also some Volkswagen executives who understood for the first time that the ICCT had found out the fraud and that the vehicles cataloged as A and B belonged to the Volkswagen group (figure 3.4). Two days before the publication of the paper on the official website of the ICCT, John German[52] informed Volkswagen that the cars listed under the names A and B were from their production, but had no response (The Guardian, 2015).

[52] Senior fellow at the ICCT

Figure 3.4 Average NO_x emissions g/km of the three different diesel vehicles tested



Source: West Virginia Report 2014, In-Use Emissions Testing of Light-Duty Diesel Vehicles in the United States, https://theicct.org/sites/default/files/publications/WVU_LDDV_in-use_ICCT_Report_Final_may2014.pdf

After the conference in San Diego, the CARB carried out further tests that confirmed the results of West Virginia University. From the test results, some vehicles exceeded the permitted limits even eighty times. At that point, the CARB began to interact with the VW company seeking explanation from the carmaker for 16 months. Instead of confessing, VW kept buy time, but CARB was constantly pressuring. VW proposed to withdraw the cars tested by the CARB to solve the problem of NOx emissions as they claimed that the cars in question were defective. They picked up the cars and sent other cars to the CARB. The cars were tested again but the result of the emissions test did not reflect the one reported on car certifications. In the hope of deceiving the CARB and thus close the case, VW had modified the manipulation plant. As the laboratory tests predict that the wheels of the car remain in the same direction, the engineers of the German automaker modified the software algorithm. With the new algorithm, pollutant control turned off automatically as soon as the driver moved the steering wheel, otherwise these limitations would cause enormous wear damage to the exhaust system. They hoped that in this way, during the laboratory tests performed by the CARB, the emissions would be within the limits, but it was not so. On 19 August 2015 for the first time, a VW employee encountered the CARB in a meeting and admitted, following

specific instructions from his superiors, that 2.0 liter diesel vehicles sold in America were equipped with cycle-beating software. On 3 September 2015, in a meeting with the CARB

Table 3.3 Volkswagen diesel cars with defeat device systems sold in Europe and U.S.

Country	**Number of cars equipped with defeat device**
United States of America	482.000
European Union	8.474.693
of witch:	
Germany	2.800.000
United Kingdom	1.189.906
France	946.092
Spain	683.626
Italy	648.458
Belgium	393.648
Austria	363.400
Sweden	224.746
Netherlands	160.000
Czech Republic	148.000
Nortway	147.139
Poland	140.000
Switzerland	128.802
Romania	105.000
Portugal	94.400
Denmark	91.000
Ireland	79.348
Slovakia	46.000
Luxemburg	43.000
Finland	26.000
Greece	9.000
Latvia	5.087
Estonia	2.041
Total amount of fraudolent cars sold	8.956.693

Source: adapted from Rik Oldenkamp et al. (2016)

and the EPA, Volkswagen officially admitted the existence of defeat devices installed on the engines of its 2.0 liter diesel vehicles (John C. Cruden, Bethany Engel, 2018, p.4). Winterkorn denied ever knowing about the defeat device installed on TDI vehicles but he was forced to resign on September 23, 2015. Soon after, Matthias Mueller, chairman of Porsche AG, took Wintercorn place and he was nominated CEO of the company on 25 September 2015. Even Michael Horn, who was VW's Chief Executive Officer and president in the U.S. during the

scandal, denied ever knowing about the manipulation software installed on 2.0 liter vehicles. Horn was one of the company's best sellers, a VW employee for 25 years. Horn's main goal was to increase sales and maintain its position within VW and do everything. During a court ruling, Horn argued that the manipulation facilities had nothing to do with the heads of management but that it was an initiative of a group of VW engineers. During a public speech Michael Horn apologized for Volkswagen's behavior by saying (John C. Cruden, Bethany Engel, 2018, p.5-6):

"I personally apologize for the use of software that served to defeat the regular emissions testing regime."

Not long after the fraud was discovered, Horn resigned as CEO of the Volkswagen Group of the American division on March 9, 2016.

On 2 November 2015, Volkswagen was accused by the EPA of having tampered with another category of vehicles produced by the automotive group. The new recall concerned an additional 90 thousand vehicles sold: the 3.0 liter engines category[53]. The vehicles equipped with accused 3.0 liter engines and reported in the NOV (Notice of Violation) included the models produced and sold between 2014 and 2016. The list reported not only the Touareg produced by Volkswagen, but also Audi A6, A7, A8, Q5 and Porsche Cayenne models. The NOV 3.0 liter reported accusations very similar to those attributed in the NOV 2.0 liter diesel engines regarding the installation of software aimed at the manipulation of performance and emissions of vehicles' engine. Again, Volkswagen tried to deny the existence of manipulation systems on 3.0 liter vehicles. However, not long afterwards the car manufacturer Audi AG admitted the violation, declaring the existence of at least three emission control devices on the 3.0 liter vehicles (John C. Cruden, Bethany Engel, 2018, p.7). On January 4, 2016, the state of New York started a civil action against VW denouncing the automotive group for fraud and for not having complied with the law and regulations on environmental pollution regulated under Title II of the Clean Air Act (John C. Cruden, Bethany Engel, 2018, p.9). During the investigations, were examined countless pages of documents, internal administration e-mails and other compromising reports. The evidence collected by the EPA and CARB was useful to

[53] 3.0 liter diesel vehicles model with defeat device where: Volkswagen Touareg (2009 - 2016), Porsche Cayenne (2013 - 2016), Audi A6 Quattro (2014 - 2016), Audi A7 Quattro (MY 2014 - 2016), Audi A8 (2014 - 2016), Audi A8L (2014 - 2016), Audi Q5 (2014 - 2016), Audi Q7 (2009 - 2016)

show that even Martin Winterkorn was perfectly aware of the fraud implemented by the automotive group. Furthermore, the investigators found that hundreds of high-level executives were aware of the installation of software for tampering with emissions.

Nevertheless, in no e-mail it appears that someone had said that they should stop doing what they were doing as opposed to law (John C. Cruden, Bethany Engel, 2018, p.5-6). As shown in Table 3.3, between 2009 and 2015, nearly 9 million cars equipped with Defeat Device Systems were sold worldwide. The largest number of fraudulent passenger cars was sold within the borders of the European Union for a total amount of 8.5 million cars. Germany appears to be the European country with the highest concentration of VW vehicles with the so-called clean diesel engine, registering a total of 2.8 million cars. America, on the other hand, has purchased a total of 482 thousand cars, less than the single Italian country which instead bought 649 thousand (Rik Oldenkamp et al., 2016).

On January 17, 2017, the United States Department of Justice, the Environmental Protection Agency (EPA), and the U.S. Customs and Border Protection (CBP) agency, put forward their final judgment on the Volkswagen case, accusing the German automaker of both criminal and civil liability. The charges were directed at the cars sold by Volkswagen AG, Audi AG and Porsche. In agreement with the United States Department of Justice, the Volkswagen Group pleads guilty to three counts. As mentioned in the press release of the United States Department of Justice of 11 January 2017:

"VW is charged with and has agreed to plead guilty to participating in a conspiracy to defraud the United States and VW's U.S. customers and to violate the Clean Air Act by lying and misleading the EPA and U.S. customers about whether certain VW, Audi and Porsche branded diesel vehicles complied with U.S. emissions standards, using cheating software to circumvent the U.S. testing process and concealing material facts about its cheating from U.S. regulators. VW is also charged with obstruction of justice for destroying documents related to the scheme, and with a separate crime of importing these cars into the U.S. by means of false statements about the vehicles' compliance with emissions limits."

VW has agreed to pay a total amount of 4.3 billion dollars fine of which 2.8 billion in criminal and 1.5 billion in Civil Environmental for the sale of indicatively 590.000 vehicles in the U.S. equipped with defeat device systems. Moreover, the automaker was forced to buy back from customers approximately 550 thousand vehicles both 2.0 liter and 3.0 liter diesel

engine (press release of the U.S. Department of Justice, 2017). In addition to the civil lawsuits against the automotive group, there were also implemented a serie of criminal cases against several individuals of the Volkswagen group who, directly or indirectly, contributed to the realization of the carmaker's fraud. The first to be charged on June 1, 2016 was James Robert Liang, the engineer of the VW America division. On 9 September 2016, the engineer declared himself completely guilty of having contributed, in his role at the Volkswagen Group, to the conspiracy of fraud for over ten years against the United State of America and American VW costumers. James Robert Liang was the first employee of Volkswagen to plead guilty to the use of defeat devices installed on cars of the automotive group. Furthermore, the VW engineer agreed to cooperate with the feds during the Dieselgate case investigation. During his testimony on the case, Liang explained that in 2016 he and other VW engineers began designing a new diesel engine for the US market. However, when the group of engineers realized that the project would not be successful due to the stringent standards imposed by Tier II in America, they decided to create a software capable of bypassing the emissions control tests (John C. Cruden, Bethany Engel, 2018, p.177). On January 11, 2017, another six Volkswagen employees were charged by the federal jury in the West Michigan district for participating in the conspiracy of the car group fraud. The accusations of conspiracy against the American state, of Volkswagen customers and failure to comply with the Clean Air Act, concerned Heinz-Jakob Neusser, Jens Hadler, Richard Dorenkamp, Bernd Gottweiss, Oliver Schmidt, and Jürgen Peter. On 6 July 2017, the Italian Giovanni Pamio, manager of the Audi car company, was also accused of participating in the VW fraud (John C. Cruden, Bethany Engel, 2018, p.178).

The giant fraud realized by the Volkswagen Group damaged several stakeholders including all those owners who purchased a fraudulent car from the automobile company between 2009 and 2015. The private lawsuits from owners of the cars equipped with defeat device systems against the German automaker were uncountable. The first cause arrived the very first day that the EPA 2.0 liter NOV was publicly disclosed on September 18, 2015. In the three days after the publication of the NOV, across the United States there were already twenty lawsuits pending against VW. Considering the rapid increase in claims by fraudulent car owners, on 23 September 2015, the Congress established a Judicial Panel on Multidistrict Litigation (JPML). JPML is an American tool used to manage and coordinate many civil

actions by subjects belonging to different legal districts but having common requests (John C. Cruden et al, 2019, p.129-130). In the U.S. Code regarding Multidistrict litigation statute[54]

"When civil actions involving one or more common questions of fact are pending in different districts, such actions may be transferred to any district for coordinated or consolidated pretrial proceedings [...]"

On April 21, 2016, the United States and California reached an agreement with Volkswagen granting all fraudulent owners' car the option of a buyback action, or close leases and rentals or to get a repair for reducing vehicle emissions. Through the recall buyback program imposed by the EPA and the CARB, Volkswagen was thus forced to take back all the 2.0 liter category cars, paying a fair price, to all those who requested it. The 2.0 Liter Consent Decree provided for Volkswagen vehicles buyback a price at least equal to the Retail Replacement Value. Consumer reimbursements, which included the value of the car returned and personal damage, ranged from a minimum of $12,500 to a maximum of $40,500. Volkswagen was obliged to start the buyback program within 15 days of the Consent Decree being issued and keeping the program open for the next two years. The buyback program cost the German automotive group approximately 10.033 billion dollars (John C. Cruden et al, 2019, p.149-151). However, although the defeat devices installed on diesel cars had the same impact and created the same kind of damage in each country where cars were sold, Volkswagen adopted different response strategies for each State. The United States was one of the few states in which Volkswagen fully paid every single sanction and legal action by consumers or government agencies. Other countries like Spain, Italy, the Netherlands, Ireland, Switzerland, Germany, and the United Kingdom will not receive the same type of treatment. In fact, in these European countries, Volkswagen refused to pay any kind of sanction or legal action by government agencies or consumers. The automotive group claimed that in Europe, beyond the cost of repairing vehicles with defeat devices, there was no reason why they should pay penalties or compensations to consumers or government agencies (Jung JC and Sharon E. 2019, p .8).

[54] U.s. code, title 28. Judiciary and judicial procedure, part iv. Jurisdiction and venue, chapter 87. District courts; venue, section 1407. Multidistrict litigation

3.3.2 The Albuquerque monkey research as an attempt to hide the truth

In 2014, driven by the obsession to promote the idea that diesel was ecofriendly, the German car manufacturer Volkswagen AG, decided on its own initiative to conduct unusual experiments on ten monkeys. Through the research, the intention of the carmaker was to hide from the whole world the fraud acted to cover the truth about the emissions of their so-called clean diesel engines and demonstrate apparent benefits linked to the purchase of their non-polluting TDI vehicles. The experiments were conducted in an Albuquerque laboratory (New Mexico) by the research institute known as "European Research Group on Environment and Health in the Transport Sector" (E.U.G.T.). The organization, charged to carry out studies to demonstrate the effects of diesel, was entirely financed by the German carmakers Volkswagen, Daimler, and BMW and it has never conducted any study of its own (Jack Ewing, 2018). Indeed, as mentioned in an article published by the New York Times in 2018, the organization Lovelace Respiratory Research Institute (LRRI) was commissioned by E.U.G.T. to conduct studies and experiments on new TDI diesel engine emissions. Dr. Jake McDonald was the scientist employed at Lovelace to supervise the experiments on the ten monkeys used for the research study. The aim of the research was to demonstrate that the new TDI technology used for the construction of diesel engines was more environmentally friendly and much less harmful to people's health than the emissions produced by the exhaust pipes of old technologies. Alex Gibney's "Dirty Money" series[55], explains perfectly how the facts of the affair went on. In order to carry out the experiments, the LRRI research institute used a dynamometer, like the one used in laboratory for homologation tests, and two different models of diesel cars. The dynamometer used during the research was chosen and delivered to LRRI laboratories directly by Stuart Johnson, head of VW's Engineering and Environmental Office. Instead, the cars compared during the experiment to demonstrate the differences between the innovation of the new diesel and the old technologies were a 2013 VW TDI Beetle and a 1999 Ford diesel pickup. The Volkswagen Beetle was delivered to the research institute directly by James Liang, engineer at VW America division and office of diesel competence. Not surprisingly, James Liang was sentenced during the investigation into the Volkswagen case for participating directly in the development of manipulation software installed on the TDI diesel vehicles of the automotive group. James Liang had access in real

[55] "Dirty Money" is an official Netflix series composed by six episodes about one hour long. It began streaming for the first time on January 26, 2018 and the first episode under the name "Hard NOx" is the one talking about the Volkswagen scandal.

time to all the data produced by the organization during the experimentations. This monitoring was necessary for Volkswagen to make sure that the defeat devices installed on the so-called TDI clean engines worked correctly and produced fake data when the vehicles were tested on the LRRI dynamometer for the misleading research financed by German car manufacturers. From the outline of the original research project, which was subsequently modified, it was discovered that in the experiments, researchers wanted to test the effects of diesel exhaust even on a human being. In other words, the idea was to place a person on an indoor bike which should have been pedaling during direct exposure to the emissions produced by the diesel vehicles used in the research study. The subject, following prolonged exposure to exhaust gases, would have been analyzed and subjected to various checks to assess the effects on health. Fortunately, no human beings were used for the experiments, but the project was done equally by replacing the original idea with the use of ten macaques. To carry out the experiments a pipe was used to connect the exhaust pipe of the vehicle and the glass chamber where the monkey was placed. The animals that were supposed to inhale the gases were entertained with TV show cartoons during exposure to pollutants. The monkeys were subjected both to the emissions of the VW beetle with a hypothetical clean TDI diesel engine and to those of the old Ford. Exposure to gas lasted from three to four hours. Subsequently, the macaques were taken to the laboratory for blood tests and other review aimed at demonstrating health effects following prolonged exposure to Diesel exhausts. At the end of the research period, before the results were published by the research institute, dr. Jack McDonald realized that the whole project and experiments were staged by VW to conceal their fraud and promote diesel vehicles for their own interests. After that, dr. McDonald refused to publish the search results (Jack Ewing, 2018).

3.3.3 Approach of Diesel technologies and defeat devices in Europe

First, it is important to mention that Germany is undoubtedly the undisputed leader in the production of diesel engine technologies. After the accusations against Volkswagen in America, in Europe, it became doubtful whether other German automakers were also using defeat device systems on their vehicles. Hans Koberstein, a journalist who took part in the realization of a documentary on the Dieselgate case after a series of researches, discovered a much more widespread problem related to the diesel pollution and its automotive use in Europe. Hans conducted a series of experiments to measure the emissions of three cars produced in Germany, including a BMW, a Mercedes and a VW that belonged to one of the

models labeled to be fitted with defeat device system. For the realization of their experiments, Hans and his research team wanted to hire a portable emissions measurement device to be fitted to the various cars on which they would conduct the tests. They contacted all the four companies in Germany that could offer a rental service for the equipment the research group needed. However, none of the four companies was willing to provide the portable measurement system for carrying out the research conducted by the journalist. Actually, the main reason why companies refused to offer the requested service was due to the fact that these companies are directly linked to the automotive industry and therefore they did not want to risk compromising relationships with their customers and damaging them somehow. As the study was a little complicated in Germany, Hans decided to carry out emissions tests on the three vehicle models in Switzerland. The experiment included the measurement of vehicle emissions through the collection of data produced both by laboratory tests and on the road under normal driving conditions. The collected data was compared to see the differences between laboratory and on the road tests. The data collected during normal driving conditions showed that both BMW and Mercedes produced emissions similar to those of the Volkswagen model, generating 40 to 50 times more pollutants than those detected during laboratory tests. The experiment was a proof that the other two car manufacturers also installed defeat device systems on the engines of their vehicles. The study conducted by Hans demonstrated that Volkswagen was not the only one to commit a vehicular emission fraud. Furthermore, it was even more surprising to find out that the fraud of car manufacturers was supported by the tacit consent of the German government. While in the United States defeat devices are considered manipulation systems, and therefore prohibited by law, in Europe, every car manufacturer uses devices to calibrate vehicle emissions. However, the definition of defeat device is the same in both European[56] and American[57] regulations. The European car-makers use the three exceptions[58] reported in the article 5 of the Regulation (EC) no 715/2007 as a justification for using calibration systems on every vehicle they produce. The exceptions of the regulation allow the calibration of emissions and therefore the handling of exhaust

[56] Article 5, Regulation (EC) no 715/2007 of the European Parliament and of the Council of 20 june 2007

[57] Section 203 of the CAA

[58] Article 5 (2):

(a) the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;

(b) the device does not function beyond the requirements of engine starting; or

(c) the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions.

systems only in particular cases to ensure the protection and safety of car engines. The German government is therefore firmly in favor of the use of manipulation systems by car manufacturers as it is convinced that these systems serve to preserve automobile engines and not to bypass the standards imposed by the European Regulation. Indeed, Europe has imposed significant standards in terms of vehicle emissions, but the problem related to the application of regulations remains a relevant obstacle. The standards imposed by European regulations must be accepted and respected by all the countries of the UE. However, the problem lies in the fact that the application and management for compliance with the rules is the responsibility of each individual country. As a result, car manufacturers orient the location of their new factories and production plants in countries where the application of standards is less stringent. In Germany, more than 10,000 premature deaths occur every year due to nitrogen dioxide pollution only. The number is greater than the deaths caused by road accidents. Nitrogen dioxide is also present there where it is not expected and not only in the busiest main streets of cities (Jonson JE, Borken-Kleefeld J et al, 2017). After the VW scandal, Europe conduced several studies on car emissions, demonstrating that diesel vehicles made a large contribution to exceeding the permitted limits in terms of air pollution.

3.4 VW Corporate Social Responsibility

Nowadays, the concept of Corporate Social Responsibility seems to be one of the major factors of competitiveness among companies nevertheless theoretical basis regarding this phenomenon started several years ago[59] (Blažek L. & Vlastimil S., 2018, p.18). Over the years several individuals exposed their thought in relation to the ethical and unethical purpose of the companies towards the society. The American engineer, Dave Packard in his famous speech "The HP Way: How Bill Hewlett and I Built Our Company" (1996) argued that often people have a very unique vision when they think to the concept of company, the majority of people think that the only reason for the existence of an organization is to make monetary profits. It is difficult to think to other reasons but nevertheless, an organization as well as having the goal of producing money can also be seen as a group of people who try together to produce something for the community that otherwise would not be able to do if they worked individually. In connection with the case, the automotive industry gives a significant

[59] CSR started in the US and moved in Europe. Between the '30s and the '50s in the US different schools of thought which attributed to the businessman social obligations that have nothing to do with the sole purpose of producing profits. The real concept of Corporate Social Responsibility began between the '60s and the '70s when the moral obligations were extended to the companies.

contribution to the development of a community by allowing groups and individuals to move freely. The opportunity of having a good mobility system guarantees the society a constant economic but also cultural development that otherwise would not exist or would be much more limited (Eriksson, Nielsen, p.4). The concept of Corporate Social Responsibility (CSR) deals with regulating the responsibility of companies for the impact they have on society. What distinguishes the CSR is the fact that alongside the economic responsibility of a company there is also a social responsibility, creating tangible and intangible values taking into consideration even everything that surrounds the company. In other words, a company can be considerate socially responsible when it considers about the effects that his behaviour makes on their stakeholders (Blažek L. & Vlastimil S., 2018, p.19). The American economist Howard Bowen said

"*A company should pursue policies desirable in terms of values of society*".

Bowen through the previous sentence wanted to explain the obligation of businessmen to pursue those policies, to make those decisions, or to flow those lines of action which are desirable in terms of the aims and values of the society. Instead, Milton Friedman[60], said:

"The responsibility of the company is to make profits"

Nowadays, for automotive companies, as well as for other companies, the production of cars that comply with the standards imposed by law is not enough to consider their production environmentally sustainable. Companies must act according to an eco-sustainable model oriented at the preservation of relations with their stakeholders by setting long-term objectives (Chiara Valentini & Dean Kruckeberg, 2018, p. 529). Milton Friedman was the first to talk about the Shareholder theory. In other words, Friedman doesn't say that companies don't have moral responsibilities, for him CSR limits in profit maximization, he says that without profit business it makes no sense, moreover he thinks in a long-term view. Nowadays, companies exist not just to make profits, they exist also to improve a society's wellbeing through implementing new value, employment of different people, providing research and contributing to taxation. In order to have a healthy society, it is essential to adopt more concrete measures so that CSR is not only an essential tool for operating in the market and for facilitating access to it but also becomes part of the culture of companies and is fully

[60] He was an American economist born in New York on 1912 and he died in 2006 in San Francisco, California. In 1976 Milton Friedman received the Nobel Memorial Prize in Economic Sciences for his noticeable study on consumption analysis, monetary history and theory and the complexity of stabilization policy.

integrated into long-term strategies, taking part in the value chain. For the strategic implementation of Corporate Social Responsibility in their automotive group system, the Volkswagen Group adopts two basic tools, which are respectively the Code of Conduct and CSR reporting. The Code of Conduct is a document used by the automotive manufacturer containing all the ethical rules that must be followed by the company workers. It supports the already existing rules, it is a useful guideline in daily work and in decision making. The purpose of this tool is to help and support workers to comply with the rules for an ethically correct behavior (Volkswagen.com, Compliance). The American philosopher Edward Freeman established the theory of stakeholders which all stakeholders become active subjects that interact with the company and affect the production chain and the company's actions. Basically, this theory identifies more specifically the subjects to which the companies have responsibility. In this case the employees are stakeholders interested in the business of the company exactly as are the customers of the American market. The workforce, however, unlike customers, as well as being interested, could with their behavior influence the management of the company. Therefore, it becomes essential to concentrate on them the attention by identifying the values to which, for better or for worse, they were sensitive. On the other hand, CSR reporting is a document periodically published both by the Volkswagen Group and its controlled companies under the name of Sustainability Report. The report contains non-financial information basically focused on issues such as the importance of employees, environment and consumers, the fight against corruption and bribery as well as respect for human rights (Volkswagen.com, Reporting). One of the main mistakes that a company can make is giving greater importance to a category of shareholder than the others. All the shareholders are equally important because they all contribute to the value chain of the company in which, in the absence of any shareholder category, it no longer makes any sense. Every shareholder must have the same importance for the company. In September 2015 the automotive group VW also won the first place in the famous and prestigious CSR ranking of the Dow Jones Sustainability Index. Obviously, when the emission fraud broke out through the EPA notification of violation, the Volkswagen group was automatically removed from the ranking list (Blažek L. & Vlastimil S., 2018, p.21). The Pakistani journalist and businessman Najam Sethi argued:

"Every firm should take a stand on issues of public interest."

Based on the previous Sethi's sentence, companies are socially involved and have responsibilities for the people with whom they are working with, then employees should have both rights and duties to fully achieve company's values. A positive social contribution towards the society can be a long-term investment in a safer and better educated community that benefits both the society but even the company by creating a stable competitive context in which to do businesses. While the concept of CSR started to make its way among the companies, Archie B. Carroll processes his pyramid of CSR in a very interesting way and never seen before. Carroll, through his pyramid, established four levels of responsibility for the companies in ascending order (figure 3.5). At the top of the pyramid there is the concept of "be a good corporate citizen" which is a discretionary choice that represents philanthropic or discretionary responsibilities and it means to do what is desired by stakeholders. Afterwards at the second level of the pyramid there is "be ethical" concept, which concerns ethical responsibilities linked to values and sense of equity, justice and impartiality of the company. It is about doing what is expected by stakeholders. In the third level we find the "obey the low" concept, which is related to legal responsibilities and it is about doing what is required by stakeholders. In the last level of the pyramid is located the "be profitable" concept which is about economical responsibilities and value creation. It refers to doing what is required by capitalism. Carroll said that a company cannot name itself socially responsible, if it doesn't have economic responsibility (Carroll, Archie B, 1991).

Figure 3.5 The Pyramid of CSR (Carrol, 1991)

Nowadays, customers take into consideration the ethical issues taken by companies when they need to make their consumption decisions, which is why companies need to be

more responsible in this field improving their organizational strategies. Considering the evolution of the market and the global dynamics, there is no more space for old business concepts, companies are forced to adopt different strategies if they want to be competitive and if they want to attract new shareholders. In the automotive market there are three important external factors that should be considered when it comes to acting in an ethically way. The automotive sector is characterized by a high level of competitiveness, continued legislative pressure from governments on reducing vehicle emissions and at the end, this sector holds an extremely important position worldwide both in economic and social terms. The high competitiveness among the various car manufacturers creates tension and generate stress among the companies and also in the internal administration, throughout managers and directors. The competitiveness on the market is mainly given by the reduction of costs and prices of the offered products. In order to offer products at lower prices, manufacturers must implement new production technologies that allow a reduction in costs and this represents the most challenging effort for automotive companies. Furthermore, the continuous evolution of the laws on vehicle emissions imposed by State governments, induce car manufacturers to comply with increasingly strict standards. To comply with these standards, automobile production requires the constant implementation of costly new technologies. In this regard, the former CEO of the Volkswagen Group Martin Wintercorn said (Blažek L. & Vlastimil S., 2018, p.21-22)

"The reduction in CO2 emissions of one-gram costs us in our fleet average a hundred million euros for development [...] It's a hundred million euros that we have to pay in advance without knowing if this investment will return."

Moreover, considering its importance at an economic but also social level, the automotive sector could be led to a moral hazard when it comes to bankruptcy. In other words, since its importance, it is easy to be misled by the so-called "too big to fall" effect because in the case of bankruptcy, car companies hope for timely help by the state. In the Volkswagen case, this factor was a crucial point into the emission fraud. Actually, the car manufacturer holds an extremely important position in the German economy. Indeed, it should be remembered that State of Lower Saxony, Hanover holds 11.8% shares of the Group and a privileged voting right of 20% at the shareholders' meeting (Blažek L. & Vlastimil S., 2018, p.21-22). These three crucial factors in the automotive sector represent the main reasons why a company may be tempted to trample ethical principles by behaving incorrectly towards

its stakeholders. Ultimately, companies should consider shareholders not simply as part of the production process, but as people, human beings who breathe, have feelings and need attention. When companies understand this, they have a winning tool in their hands. However, as Chiara Valentini & Dean Kruckeberg claim (2018), although consumers are increasingly aware and particularly sensitive to the issue of environmental pollution, their purchasing preferences are more influenced by cost factors and vehicle performance. Therefore, what drives car companies to invest in CSR is not just a direct demand by consumers to buy cars that respect the environment, but there are a series of other reasons. There are basically four main reasons that justify the adoption by the automotive industry of practices oriented towards eco-sustainable production. First, companies are driven by an instrumental motivation to support the main economic reason of the company's business. Consequently, the adoption of CSR practices by companies can be a useful tool to improve financial performance, attract new consumers, avoid penalties and reminders and improve the reputation of the company brand. This may be an explanation for the investments made by the automotive industry in sustainable production to overcome the recent financial crisis that led to an inevitable collapse in demand. The second justification is of political origin. Companies agree to actively engage in social work in order to be entitled to participate in social and decision-making collaborations. Another motivation for investing in CSR actions is due to the adoption of theories aimed at stakeholder orientation. A company that adopts a socially responsible behavior will be more attractive for the demand of the stakeholders. Especially in recent years, investors in automotive companies have been particularly influenced in their investment decisions by the CSR policies adopted by car manufacturers. The implementation of government models oriented to an eco-sustainable production attracts stakeholders and consequently this creates prestige and notoriety for automotive companies. Finally, the ultimate motivation for companies to invest in CSR activities is driven by ethical reasons. The adoption of ethically correct practices represents the so-called "the right thing to do", a principle that every good company should adopt for its business (Chiara Valentini & Dean Kruckeberg, 2018, p. 530-531). From the analysis several studies conducted on the Volkswagen emission fraud case, it emerged that the main reason that would have led the car company to adopt an unethical behavior, by manipulating the emissions cars system, is due to the aim of becoming the largest automobile manufacturer worldwide by 2018. This long-term goal was developed by the company in 2007 by implementing it in the so-called "Strategy 2018" document. In addition, there was also another long-term goal that lead the company to

act fraudulently, or the idea to increase the production and sale of diesel-powered vehicles on the North American market. These extremely rigid and ambitious goals have led to significant corporate culture changes within the automotive company. It was requested that the objectives be achieved at any cost and any objection to their feasibility was interpreted as disloyalty to the company or as a manifestation of incompetence. The company organization was pervaded by a constant psychological pressure for which "I can't" couldn't exist and mistakes could not be forgiven. Moreover, the fraudulent behavior adopted by the Volkswagen group is also partly due to the belief that the automotive group had the protection of the German state and therefore they thought that everything was allowed to them. The automaker had certainly underestimated the risks and consequences that this fraudulent behavior would bring especially in the long run. From investigations, it emerged that the blame for the conspiracy and installation of fraudulent software cannot be attributed only to a group of enterprising engineers at VW. The misconduct of the VW group has been shared by many more people than one could imagine and only the fact of having been aware of what was happening without objections is guilty of what happened. Obviously, the two documents discussed above, Code of Conduct and Sustainability Report implemented by VW to guide the company to ethically correct conduct, were not useful to avoid the fraudulent actions. In conclusion, it should be underlined that the implementation of corporate social responsibility documents doesn't represent a guarantee of success of them without serious supervisions from the top of the management control (Blažek L. & Vlastimil S., 2018, p.23-25).

Chapter 4 Current situation of the Volkswagen Group and Diesel market

For years the automotive group, through deceptive advertising campaigns promoting a so-called "clean diesel" engine, has filled people's homes all over the world with uncountable lies. It comes naturally to ask what the reaction of people was when they discovered they had been deceived by a car company that only aspired to achieve its goals in financial and prestige terms. What impact has had the emission scandal on the company's brand image and how sensitive are people to the Dieselgate case five years after the discovery of the fraud by the Volkswagen group? Considering individuals perception, what percentage of the population has really cleared the impact and effects that diesel engines have on people's health and the environment? In this chapter various issues related to the consequences of the VW emissions scandal and the current situation of the automotive group will be discussed. Furthermore, the actual perception that individuals have towards the automotive group, on emissions, on

pollution, and the willingness to pay to have sustainability-oriented companies. Moreover, with the election of Trump, the federal government has announced that corporate profits will have priority over environmental protection by withdrawing from the Paris agreement on environmental protection. Thus, the United States, Syria and Nicaragua are the only three nations that will not contribute to limiting global warming. Moreover, the Trump administration has also threatened to weaken the CARB due to its strict controls on air pollution.

4.1 Volkswagen recovery and today' market shares

From studies and surveys conducted after the discovery of VW's fraud by the authorities, it emerged that the sales volumes of the automotive group have not undergone significant collapses despite the fact. This shows that the perception of the car brand by consumers has not undergone significant negative consequences (Blažek L. & Vlastimil S., 2018, p.24). However, the damages suffered by the car company following the discovery of the fraud were substantial and not indifferent. The guilty plea deal agreed by the Volkswagen Group in January 2017 amounted to a total of 4.3 billion dollars, of which 2.8 billion in criminal penalties and 1.5 billion in civil penalties. The carmaker sales suffered a 20 percent drop in November 2015 and a further 10 percent in October of that year. Auto sales continued to decline for the next twelve months following the Notice of Violation published in June 2015 by the US Environmental Protection Agency. In January 2017, the amount of civil cases and consumer complaints in the US cost the Volkswagen 14.7 billion dollars. In addition to the financial damages due to criminal, civil and reimbursement of consumers who had started civil actions against the car group, there were also a series of personnel losses. In fact, numerous employees of the Volkswagen were investigated and charged with the conspiracy of fraud against the United States of America and American consumers (Welch J., 2019, p.5-6). Furthermore, the company's shares have gradually declined since 2015 when the VW group was accused by the American authorities. The shares went from 230 euros per share in April 2015 to 160 euros per share after September 18, 2015 and finally in October 2015 the lowest price ever was recorded; the VW shares amounted to 102 euros or a 42% decrease compared to the highest price recorded that year. However, in the following months the shares started gradually to grow back and at the beginning of 2017 the price reached a level of 150 euros per share. Following the outbreak of the scandal, the American credit rating agencies began to reduce its rating and negatively mark the shares of the VW group. On 24 September

Table 5.1 Volume and Financial data of Volkswagen Group before and after the scandal

Volume data in units	**2014**	**2015**	**2016**	**2017**	**2018**
Vehicle Sales	10.217.003	10.009.605	10.391.113	10.777.000	10.900.000
Production	10.212.562	10.017.191	10.405.092	10.875.000	11.018.000
Employees	592.586	610.076	626.715	642.300	664.500
Financial data in €/million					
Sales revenue	202.458	213.292	217.267	229.550	235.849
Operating result	12.697	- 4.069	7.103	13.818	13.920

Source: adapted from VW Group annual report 2014,2015,2016,2017,2018

2015, Moody's agency replaced the original positive A2 rating of VW's shares with an A3 negative one. Standard & Poor's rating agency, on the other hand, marks the shares of the automotive group with a negative BBB + rating. It is important to underline that before the scandal the company was labelled with a positive A evaluation. The 2015 and also part of the early 2016 represented for Volkswagen an extremely tough period to overcome (Blažek L. & Vlastimil S., 2018, p. 25). Following the public revelations about the Volkswagen fraud, numerous opinion leaders and analysts in the automotive industry had argued that with a scandal of such dimension, the car manufacturer brand would have found a permanent drop in sales and a drastic negative impact in perception of the car brand by consumers. However, considering the size of the damage caused, the Volkswagen group uses very little to overcome the storm and restore the damage. In fact, just six months after the agreement on criminal and civil charges against Volkswagen in June 2017, the car company recorded a 15 percent increase in sales compared to the same month of 2016 and a 5 percent increase compared to total sales for the entire previous year (Welch J., 2019, p.3).

The main objective of Volkswagen immediately after the scandal was to limit financial damage and to maintain stability. This goal was achieved in a short time and without too much effort thanks to the reduction of costs and pay-outs (Jung JC & Sharon E., 2019, p.7). It is extremely interesting to note that just 12 months after the scandal, Volkswagen has returned to the top of the car rankings, overtaking Toyota and General Motors and regaining first place as the world's automotive manufacturer. Already in 2016, Volkswagen recorded 3.8% sales increase for a total of 10,312,400 vehicles sold compared to 9,930,500 vehicles sold in 2015.

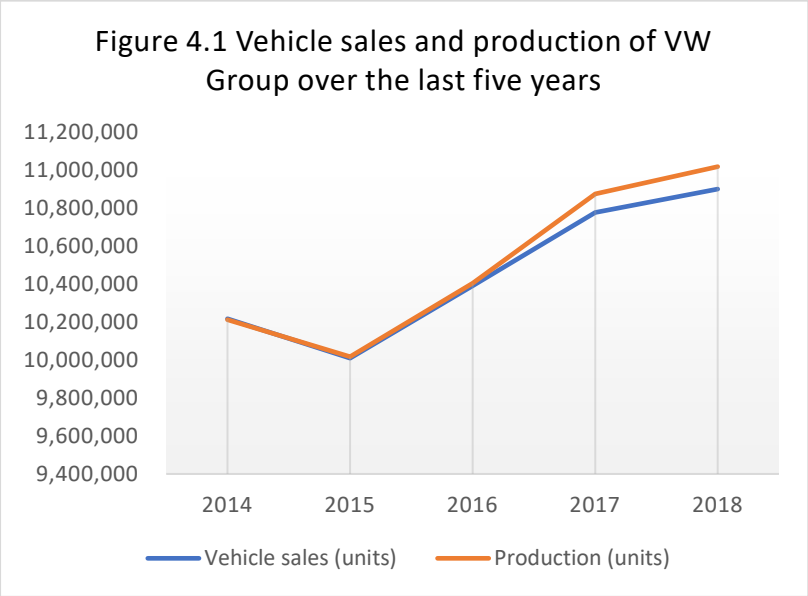


Figure 4.1 Vehicle sales and production of VW Group over the last five years

This extremely rapid recovery of Volkswagen is basically due to the adoption of four steps: Replace, Restructure, Redevelop and Rebrand. The four steps involved the adoption of significant changes both in terms of organization, leadership, strategy and rebranding. The strategic adoption of these four steps led the automotive group towards a rapid and unexpected recovery from what was thought to be a catastrophe with no way out (Welch J., 2019, p.7).

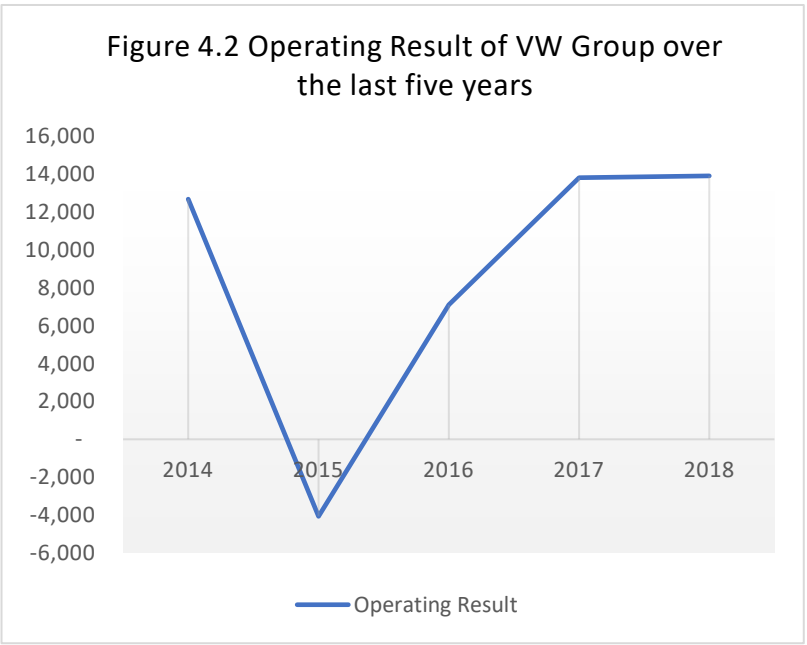


Figure 4.2 Operating Result of VW Group over the last five years

As can be seen from table 4.1, both sales and production volumes as well as the operating result, have suffered a drastic drop in 2015. However, the speed with which the numbers start to rise again since 2016 is quite incredible. In fact, as shown in Figure 4.1 and 4.2, the drop in sales, production and operating result has an extremely steep descent but the recovery is more than proportional. The biggest sales growth during VW's recovery period was in countries with developing economies such as China (a 20% increase) and Eastern and Central Europe (a 21% increase). In the United States, sales fell by 8% in 2016, but already in 2017 there was a positive recovery result with an increase of 5.2% (Jung J.C. & Sharon E. 2019, p.7). There is a small stalemate about the operating result between 2017 and 2018 with an increase of only 0.7 percentage points (table 4.1). As

for the employees of the VW group, the numbers have never suffered a decline, not even in 2015 remaining constantly increasing (table 5.1). However, despite the rapid financial recovery and sales volumes, Volkswagen is still dealing with various lawsuits and complaints from several countries around the world. The toughest challenge for the automotive group to overcome is still to regain numerous groups of stakeholders, and this process takes a lot longer. As for the brand image, from a study carried out on 800 American individuals, a few months after the publication of the NOV by the EPA, it emerged that only 7.5% of consumers surveyed had a negative impression towards the Volkswagen brand. Consumers were much more disappointed and upset at the impact that defeat devices had on the performance of their cars rather than on the issue of polluting emissions (Jung J. C. and Sharon E. 2019, p.7-8).

4.2 Future perspectives and aims of the Volkswagen Group

In the last 2018 report of the Volkswagen group, in the letter addressed to the company's shareholders, the Chairman of the Board of Management of Volkswagen AG, Herbert Diess claims (VW group annual report 2018)

"Our emphasis is on electric car, because from today's perspective it is the best and most efficient choice for reducing CO_2 in transport"

Following the diesel engine tampering scandal, the Volkswagen automotive group has implemented a new strategy to produce eco-friendly cars with electric engines. At the 2019 Shanghai auto show, the car manufacturer announced a new strategy to produce 22 million electric cars by 2028. Still in the letter to the shareholders, Diess discuss about a new campaign focused on the electrification of the vehicles of the car manufacturer in order to respect the Paris pact and to contribute to the protection of the environment and the health of people. The Volkswagen group will invest about 30 billion euros over the next five years for the construction of electric vehicles.

4.2 People's perception of diesel after the scandal

The future of the automotive industry in terms of vehicle fuels and the switch into alternative energy is still a question without responses for many aspects. This uncertainty is given by variables such as the future adoption of new and increasingly rigid standards by governments but above all, the evolution of the automotive industry will be driven by consumer consumption decisions. The consumers' car purchase decisions are influenced by several factors including preferences related to the design, performance and safety of the

vehicle, the type of engine fuel-power, their using needs and habits, age and cultural background, economic availability, but also from pollution awareness guidelines, beliefs and impressions on automotive brands. Every individual identifies, before every decision of a car purchase, constructs in his mind, consciously for some aspects and unknowingly for others, a framework with all the variables that influence his decisions purchase. Consumer demand is the main lever in any sales market, within the limits allowed by law. In the automotive market, the limitations in terms of emissions imposed by the law significantly limit market freedom. However, even in this case, consumer demand plays a fundamental role in driving industrial production (2019 Deloitte Global Automotive Consumer Study). In definitive, the aim of this research is to better understand the consumers consumption orientation within the automotive market, their perception and sensitivity to environmental problems due to vehicular pollution, awareness of the Volkswagen group emissions fraud and propensity to purchase eco-friendly vehicles.

4.2.1 Method

This quantitative research uses an online survey questionnaire with the aim of a better understanding of the automotive market orientation in the future and to comprehend consumers' perceptions towards diesel-powered vehicles, especially after the broke of the Volkswagen scandal. A quantitative research focuses on the relationships between variables aiming to understand and explain the reasons why variables are linked each other. The quantitative research selects and analyse a group of people based on the variables of interest to answer the questions raised by the research. People are the main unit measure of quantitative research. The questionnaire represents the fundamental research tool for data collection in a quantitative research. This tool uses specific research questions aimed at collecting variables that could have a relevance and relationships between them (Punch, KF, 2003, p. 29). The questionnaire was created with "Google Surveys", a market resource platform made available online by Google. The survey was carried out on a sample of randomized subjects without the application of any control variable. The only control variable applied was the participants' age. The "age" control variable was deliberately introduced due to the specificity of the subject matter. In fact, I wanted to exclude from the survey the branch of the under-age population since it presupposes that minors are not in possession of a driving license and therefore probably less susceptible to the theme of the investigation. Excluding the under-age population, the questionnaire was proposed in a completely random manner to individuals of both genders, of all ages and regardless of educational level. The geographical

radius of the experiment has a greater concentration on the Italian population and a smaller number of the participants is represented by individuals from other countries around the world. The questionnaire includes a series of master data questions that help the separation of individuals into more homogeneous groups to increase the validity of the results. Furthermore, depending on whether individuals are owning or not a car, different sections are proposed to lead participants through the survey and ask specific questions in each target group, as well as to facilitate the data processing and management. The questionnaire was filled out by 271 participants.

4.2.2 Data Collection

The data of this study was collected using an online survey. The participants were selected in a completely random way with a non-probabilistic sampling method (snowball sapling). For the randomized selection of the participants to the survey I used digital communication tools and social-media platforms such as Facebook, Instagram and LinkedIn, as well as I allowed the sharing of the questionnaire by word of mouth. The questionnaire began in November 2019. The questions of the survey were written in English. To facilitate the understanding of the questions by the Italian population, the questions have been translated into Italian. To guarantee the homogeneity of the answers and the equivalence of the concepts, the answers were back-translated into English language and aggregated to the others.

The questionnaire is mainly divided into four macro-sections. The first section, mandatory in all its parts, concerns the status survey of the research. The questions in the status section divide individuals based on age, gender, geographical location, level of education and finally a screening application linked to the possession or not of a vehicle. This last question conveys individuals to the next section based on their response. Those who answer for owning a car are leaded to the section on car owners, as well as those who respond to use a car in common with other people are transferred to the dedicated section. Those who answer that they do not own or use any car are transferred to the last section that deals with topics common to all participants. In the section on the use of a vehicle shared with other people, individuals are asked to indicate who is the main owner of the car, the willingness to change or not the current shared vehicle, motivating the response and finally individuals are asked about the desire to own a personal car. At the end of this section the individuals sharing a car with others are redirected to the same section dedicated to car owners as the questions

concerning the vehicle and are common to both groups. In the section dedicated to car owners, a section to which also those who use a shared vehicle are also subjected, they are asked for information regarding vehicle fuel-powered type, time frame of ownership and use of the vehicle, main purpose of the use of the vehicle and grade of importance attributed to the ownership of a vehicle based on a scale from 1 to 5. Finally, the last section that is administered to the all participants, pose questions relating topics such as diesel-powered engines, vehicular pollution, eco-sustainable energies, Dieselgate scandal and Volkswagen car brand. The questions in the last section are 10. The first question asks individuals about the perception of diesel-powered vehicles, the second question concerns people's awareness of the pollution caused by diesel engines, then the third question is about the sensitivity degree of pollution caused by diesel engines, the fourth question is a survey of the type of engine consumers would buy if they had to change their car in the next year with a subsequent request to motivate their previous answer. From the sixth question I introduce the Diselgate theme by questioning the interviewees about the knowledge of the term and those who answer to know the case are then asked to indicate between a series of different brand which of them had been implicated in the Dieselgate case. The eighth question asks consumers if they know what happened to Volkswagen in America in 2015. Those who respond positively to the eighth question are asked to express an opinion on the perception they have today of the car brand considering what happened. In the last question, individuals are asked about the future of the Diesel market, whether they think about a future without diesel or if they believe that diesel will never come out of the automotive market.

4.2.3 Data Analysis

Status survey analysis

Table 4.2 Demographic and car ownership profile of partecipants

	All the participants			Italian participants	
	n = 271	%		n = 239	%
Gender			**Gender**		
Male	199	74	Male	179	74,9
Female	72	26	Female	63	26,4
Age			**Age**		
Mean	33		Mean	32	
Median	28		Median	28	
Range	18 - 66		Range	18 - 66	
Educational level			**Educational level**		
Compulsory education	54	20	Compulsory education	52	22
Baccalaureate	40	15	Baccalaureate	36	15
Bachelor's degree	74	28	Bachelor's degree	67	29
Master's degree	77	29	Master's degree	63	27
Doctoral degree	21	8	Doctoral degree	17	7
Vehicle owners			**Vehicle owners**		
Owner	204	77	Owner	184	78
Shared car	39	15	Shared car	34	15
Non owner	23	9	Non owner	17	7

The overall number of participants at the questionnaire was 271 people. Table 4.2 shows the demographic data and the variable of car ownership of the survey participants. As can be read from table 4.2, the number of male individuals greatly exceeds that of women, in fact the males who answered the questionnaire are 201 (74% of the total amount of samples) while the females are only 70 (26% of the total number of participants). The sample of subjects is aged between 18 and 66 and the average age is 33 years while the median is 28 years. Asked about education, 54 participants replied that they had completed compulsory education, 41 had graduated, 78 had completed a bachelor's degree, 77 had a master's degree and 21 replied that they had done a doctoral degree. In terms of car owning, 208 individuals declared to own a car, 39 use a car in common with other people and 24 claimed not to own neither use any car. The number of participants living in Italy, 239 Italian residents represent 88% of the total number of respondents. The remaining 31 individuals come from different countries worldwide and represent only 12% of the study research. The 31 individuals come from Colombia, Kazakhstan, Colorado, Connecticut, New Jersey, Morocco, Croatia, Albania, Austria, Belgium, Manchester, London, Finland, France, Romania, Spain and Switzerland. The Italian segment to which the questionnaire was administered (239 individuals) is divided into 179 males and 73 females. Again, also in this case the male gender covers a larger slice of the survey with 74% of the total of the research samples while the female represents only 26%. Age variables almost entirely reflect those on the overall analysis of all participants as well as the educational level and the variable of car owner.

Car sharing drivers

The percentage of the population who responded to driving a shared vehicle with other people was asked to indicate the main owner of the vehicle. Out of 39 people, 12 indicated that their mother was the owner of the vehicle used, 12 of them cited their father as the vehicle owner, 9 indicated themselves as the main owner, and 4 indicated other subjects as a brother, husband, mother-in-law or grandfather. Still the same category has answered the question relative to the desire to replace the current vehicle in use with another one. The majority (49%) has expressed the wander to change the actual vehicle while 41% claimed won't change the car. Finally, four of the interviewees expressed indifference to the idea of changing vehicle. The main reasons for those who would like to replace the vehicle are: wear of the vehicle, excessive consumption, desire for a new and personal car, inadequacy to the needs, desire to purchase a hybrid or electric car, desire for an innovative vehicle, desire for a car with greater driving performance, disagreeing with the vehicle brand. Those who would like to keep the vehicle express reasons such as: limited use of the car, vehicle bought recently, satisfaction of the performance and safety of the vehicle currently in use, low fuel consumption, the vehicle meet their personal needs. In the last question of the macro section dedicated only to drivers of shared vehicles, 70% of the subjects expressed their willingness to buy a car for personal use in the near future and only 2% said they don't aspire to have a personal car. Instead, 28% expressed uncertainty in the purchase of a personal car in the near future.

Vehicle data and vehicle employ

In the section that unites all drivers who were given the questionnaire, they are asked to indicate the type of power supply to the vehicle in use. From the graph developed automatically by the "Google Survey" platform, it can be immediately noticed that the engine fuel market is mainly dominated by diesel and petrol engines. In fact, 33% of the vehicles used by the participants are fueled by petrol while 51% are diesel-powered engines. Only 8% of consumers surveyed have an eco-sustainable vehicle (15 LPG vehicles, 4 hybrids, 2 electric and none with methane).

Table 4.3 Participants' vehicle fuel power and avarage of vehicle detention based on fuel type

Vehicle fuel-power	n = 244	%	average duration of vehicle ownership
Diesel	136	56	4,5 years
Gasoline	87	36	4,7 years
Liquefied petroleum gas (LPG)	15	6	3,2 years
Liquefied petroleum gas (LPG)	-		-
Electric energy	2	1	-
Hybrid	4	2	-

The average holding of consumer vehicles involved in the survey is 4.43 years. If we look more specifically by selecting the time data based on the vehicle's fuel, we see that the average does not change much. In fact, for diesel-powered vehicles, the average holding time of the current owner is 4.5 years while for petrol the variation is slightly higher with an average of 4.7 years. For other types of engines, the amount of data is not enough to support a statistically valid hypothesis (table 4.3).

In terms of vehicle use, participants' responses converge on a large scale on a few common points to most consumers of the automotive industry. The cars of the interviewees have the main purpose of means of transport to reach the workplace (61% of the answers). The second reason for using the vehicles is to enjoy free time, this factor represents 52% of the total answers. Subsequently, considering the younger group of individuals, the vehicle is used by students to reach the educational institution (e.g. school, university) registering 12% of the answers. 18 people responded that the possession of a car also represents a status quo.

Table 4.4 Diesel perception of the consumers

n = 271					
Pro		*Cons*		*Neutral*	
n	%	n	%	n	%
121	44,6	84	30,9	66	24,4
Less fuel consumption		Environmental pollutant			
More performance		Less engine quality than gasoline ones			
Limited maintenance					
Reliability		Out-dated technology			
Less polluant than gasoline		Costly vehicles			
Best efficacy and efficiency		Noisy engines			
Vehicles are cheaper		Not indispensible for the future			
Engine power					
Esier to drive					
Better for long journeys					
Engines got a much longer cycle of life					
Powerful					

On a scale of importance from 1 to 5 where 1 means that the possession of a car has no importance and 5 represents the extreme importance of possession, 58% replied that the availability of a vehicle owned is extremely important (5), 18% answered 4, 4% replied 3, 2% answered 2 and 4% of individuals claimed that the car has no relevance for them (1). In the last macro section that involves all the participants submitted to the questionnaire, the specific theme on diesel engines is introduced. To the question: "what do you think of diesel-powered vehicles" among the main answers emerge concepts such as pollution, fuel consumption, efficiency, vehicle longevity, long distances to travel, ease of driving (Table 5.4). The most discussed topic is certainly the one related to pollution and fuel consumption. The opinions completely favorable toward diesel are 45%, those completely unfavorable are 31% while those who have expressed indifference, ignorance towards the subject or have simply provided a description indicating pros and cons are 24% (Table 5.4). Among the several answers

"Producing electric powered vehicles pollutes environment 10x more than diesel cars and the electric energy comes from nuclear power plants, coal plants etc. If you want to save the

environment first, you have to have completely green economy that is sustainable and quit the idea of never ending story of economic growth and capitalism"

"Excellent vehicles, I work in the automotive world and most of the vehicles sold and repaired are diesel powered. Maintenance is minimal and performance is high"

"I think they are harmful to the environment, but at the same time I don't believe that there are substitutes, both in terms of reliability (electric cars) and in terms of price"

"Surely the cost of diesel is lower than the price of petrol. For me it is very important as I travel many kilometers on the car"

"If electric cars would be more accessible and gasoline didn't cost that much, I'd eliminate them from the market"

"Noisy, not very suitable for sports cars even if they are powerful. Delicate, requiring too much maintenance. In some respects (particulate emission) too polluting. A real car enthusiast would never drive a diesel engine one!"

"Diesel vehicles are losing competence in markets because of technical problems in its pollution system and probably they pollute as well as a not diesel vehicle"

Afterwards, the participants were asked if they were aware of the impact and the consequences that Diesel engine emissions have on people's health and on the environment. 224 respondents corresponding to 83% of the total claimed to be aware of the damage caused by diesel emissions, 36 responded no (13%) and 11 expressed disregards for the topic. On the level of sensitivity to air pollution caused by motor vehicles a scale of importance has been proposed at five levels: Ultra-Sensitive (23 participants, 9%), Highly-Sensitive (89 participants, 33%), Moderately Sensitive (121 participants, 45%), Normal (32 participants, 12%), Not Sensitive (I don't care about this issue) (6 participants, 2%). The next question asked participants to indicate the type of power supply to the vehicle they would choose if they were to buy a new vehicle and the result is immediately evident from the charts automatically created by the "Google survey". The majority of individuals, 46%, stated that they are directing their future purchase decisions towards eco-sustainable cars and 20% express their preference for hybrid engines. Only 19% of respondents chose the "diesel engine" option while 14% expressed their support for the purchase of a petrol engine in the near future. The main reasons for their purchasing preferences with regards to eco-friendly energies were on topics such as: economic incentives provided by car manufacturers, state

economic advantages, concessions in urban traffic, eco-sustainability, lower costs. Among the several answers:

"I will choose a hybrid engine because the choice is greater. There are incentives to purchase supplied by car manufacturers and they are accompanied by state economic benefits such as car tax (stamp duty), purchase incentives (not yet issued), facilitated access in metropolitan areas"

"The new cars are beautiful in design, but also eco-friendly in most cases, perhaps the only one that holds back a bit are the costs"

"Alternative fuel powered engine Cars are less pollutants and they have tax relief"

"Electric are the best, but little incentive from the state regarding the price to be sustained for the purchase"

"Sustainability, possibility to move more easily in restricted traffic areas, more favorable purchase conditions due to facilitated taxation and / or tax relief"

"economic refueling and distributors present in a capillary way, a motor with good performances that does not require any particular maintenance"

Those who responded that they were more favorable to hybrid engines for the future, in addition to motivations such as consumption and environmental protection, expressed a desire to have a compromise between tradition and innovation.

"I would take a Hybrid also MILD Hybrid, but on a Diesel engine basis, like Hyundai Tucson Hybrid 48V. Because it combines low fuel consumption and driving spiritedness of the Diesel with the environmental aspect"

"Diesel= pollution, electric engine will affect my lifestyle (long charging Times, autonomy for small distances), so I think hybrid cars are a fair compromise"

"Unfortunately, it's not yet time to full electric vehicles. we don't have enough chargers. However, hybrid could the right alternative"

Regarding the motivations of those who want to maintain traditional diesel engines, the reasons remain mainly those related to fuel consumption, performance, reduced diesel

cost, value for money, long distance driving distances, long-term engine resistance. However, the majority have expressed reasons related to economic factors.

"Petrol has too high consumption, Electric hybrid etc costs too much, Diesel remains the best alternative "

"It would be hypocritical to buy petrol, electric, LPG and CNG cars. If you don't want to pollute, you go by bike. Secondly, the production of electricity takes place through the combustion of fossil energy, methane pollutes 4 times more than the monoxide, LPG well, what's the point? "

"I have traveled and traveled a lot. in Europe we are also too far ahead from an eco-sustainability point of view compared to most of the world. from a global point of view the incidence of pollution caused by European private cars is irrelevant"

Finally, those who would opt for the traditional petrol-powered car express opinions linked to less pollution than diesel engines, the purchase of vehicles has lower costs, limited engine noise and performance.

"Production of electric vehicles pollutes more and charging them also. I have no problem using alternative fuel like methane or synthetic gasoline which also pollute less than production of electric cars"

"Nowadays, the gasoline engine is still the best solution. Hybrid or electric engines are too expensive and do not yet have a "valid range, CNG or LPG engines have a limited distribution network"

"It is proved that gasoil vehicles are the most convenient in terms of comfort. New alternatives are still in evolution and not efficient at all for consumers expectations"

The next step of the questionnaire introduces the arguments related to the concept of Dieselgate and the Volkswagen Group emissions scandal. To the question "Have you never hear about Dieselgate?", 42% of people said they had never heard the term Dieselgate, 52% expressed their knowledge of the term and 6% of participants expressed uncertainty. Those who responded affirmatively to the question about the knowledge of the term Dieselgate were subjected to a test to see if they really had the concept clear. The test asked participants to indicate between a number of listed car brands, which had been involved in the Dieselgate

case. Of the 147 individuals who underwent the test to understand the real knowledge of the term Dieselgate, only 137 responded Volkswagen, 44 answered Audi and 14 replied Porsche. The other most relevant answers were BMW with 21 people who referred to it as a brand involved in the Dieselgate case, Renault which was indicated by 12 people and Mercedes-Benz which instead selected it in 14 people. As for the scandal that broke out in America in 2015 due to the discovery of Volkswagen emissions fraud, 31% of people claimed that they never knew about the incident and the remaining 69% said they knew the facts. Those who stated that they were aware of the Volkswagen fraud were asked to express an opinion regarding the perception they have towards the automotive group following the incident 81 people replied that they were disappointed by the VW brand and that they had a negative opinion. Feelings of anger, disappointment and loss of confidence were expressed. The other 88 people who gave an answer expressed indifferent opinions or stated that their perception of the brand did not change following the discovery of emission fraud. Finally, the last question concerned the perception of the future of diesel. 52% of respondents who represent the majority are convinced that diesel engines will only come out of the automotive industry in part. On the other hand, 32% claim that diesel engines will completely disappear from the market, while for 13% of participants diesel will never leave the automotive market. The remaining 3% did not know how to express an opinion.

4.2.4 Results

The survey showed that even today many people own cars powered by Diesel despite the pollution due to the discharges of this fuel is a topical issue that touches each of us in first person. 56% of respondents own or use a diesel-powered vehicle in common with others. This may mean that despite the dissemination of information through the press, educational institutions, mass media and other forms of communication, people have given priority to other variables on the scale of importance when they bought the vehicle. Considering the average of the possession of diesel vehicles by the participants which was 4.5 years, this data indicates that these are not vehicles bought many years ago when not much was known about the pollution of diesel engines but on the contrary this data indicates that at the time of purchase the pollution variable did not have much relevance in the decision to supply the vehicle engine. Making a cross analysis to see if there is a relationship between the age and diet variables of the vehicle possessed, there was no significant deviation from the average age of all participants. The average age of those who own or use a diesel-powered vehicle in common is 34 years, while for petrol-powered vehicles the average age is 30 years. The

average age of all participants is 33 years. Even the medians (general 28 years, 30 years diesel vehicle owners and 26 petrol vehicle owners) remain very close to the general figure on all participants. To narrow the field, excluding all those who do not use it, they own a vehicle and all those who have not responded to the question on vehicle power, the average age of all drivers is 32 years and does not differ much from that registered on all participants (33 years).

Consequently, it could be said that in this analysis the variable age has no influence on the type of engine owned by the participants. In the survey the number of people who responded that they were aware of the impact that diesel vehicle emissions have on the environment and on people's health was very high, however from the answers given to the request to express an opinion on diesel engines, several participants replied that diesel vehicles "pollute less than gasoline", "They are as polluting as gasoline, but with better consumption performance", "Pollutants like others, recent euros give little impact", "I think the latest technologies have made them less polluting "," in my opinion they are efficient and pollute less than the gasoline engine "and even" For me they pollute less than others. if useful measures are adopted ". These data suggest that many people are convinced that they are adequately informed about the issue of vehicular pollution but in fact, their knowledge still has many gaps. Investigating whether age affects the degree of sensitivity to pollution in motor vehicles, it emerged that the average age for each degree of sensitivity (Ultra-sensitive 33 years, highly-sensitive 33 years, moderately sensitive 33 years, neutral 31 years, not sensitive 28 years) does not differ much from the average general age. Therefore, the age of the participants does not influence the degree of sensitivity to the pollution of motor vehicles. Considering the disparity in the number of male and female respondents, no hypothesis can be made by taking the gender as a variable in relation to others.

Despite the large share of participants owning or using a diesel-powered vehicle, it is interesting to note that asking participants their preference in terms of vehicle engine if they would buy a new car next year, the trend clearly shifts to alternative fuel options by choosing eco-friendly and hybrid cars. This could mean that there is a good chance of reducing the consumption of diesel cars very soon. Motiving their choice, those who declared that they had a propensity to purchase oriented towards eco-sustainable energies the most cited word was "pollution". In fact, eco-friendly cars, as explained in the previous chapters, have a significantly lower impact on environmental pollution. There are several incentives provided by some states and some car manufacturers to attract consumers to purchase eco-sustainable engines. However, there are still several obstacles that do not encourage the purchase of these

vehicles. Factors such as vehicle cost, limited performance compared to traditional engines, traffic restrictions, difficulty in finding the fuel needed by the vehicle or columns to recharge electric vehicles.

Regarding the knowledge of the Dieselgate case, in a cross-investigation it was found that people with a higher education level tend to be more informed on the subject than those who are less educated. However, many of those who said they knew about the Dieselgate case pointed to vehicle brands that had nothing to do with the subject in question. The wrong answers were 117. As for the Volkswagen emissions fraud, it is surprising to note that despite the size of the scandal, many people have never heard of it. As many as 83 people (30%) replied that they were not aware of the incident. Beyond the excellent damage management capabilities of the Volkswagen administration, one would also think that the resumption of the automotive group's sales and the brand's image could also have been partly influenced by the fact that an important slice of consumers has never heard of what happened. Moreover, many of those who are aware of the facts have claimed that they have not changed their perception towards the automotive group, which they consider one of the best producers in the world. Some replied that VW was not the only one attempting to circumvent the rules, and therefore perceive the incident as a predictable and irrelevant thing. Finally, regarding the future of the diesel market, the idea most shared by the participants is that diesel will only partially and never completely exit the market.

4.3 The automotive market in USA with Trump

The automotive industry plays a very important role in the US economy and consequently has a strong influence on both democratic and republican American political parties. In America, Democrats are the political party most sensitive to environmental problems, while the Republicans have always maintained that the economic interests of American companies had priority over issues related to environmental protection. (Pavone IR, 2018, p. 39). Already during the election campaign, even before being elected president, Trump declared his intention to withdraw the U.S. by the Paris climate agreement in the event it is elected. The Paris agreement was born on 11 November 2014 from the affair between the United States of America under the Obama administration and General Secretary of the Communist Party of China Xi Jinping. Through the Paris agreement, China expressed for the first time its will to reduce polluting emissions to safeguard the health of the Chinese population. Several states from all over the world adhered to the agreement between the US and China, sharing the

objective of reducing carbon emissions between United Nations Framework Convention on Climate Change. The agreement, also known as COP21, was signed by 195 nations. The United States of America, which represents the state with the greatest amount of per capita carbon emissions, signed the agreement under the Obama administration with the goal of reducing emissions by 2025 from 26% to 28%. The agreement acknowledges that it cannot demand either drastic emission limitations for developing countries or those with developed economies. To incentivize states to join the Paris agreement and help limit global pollution as much as possible, the Obama administration had decided to limit the obligations contained in the agreement to a very low level. However, all the efforts made by former President Obama to limit polluting emissions have been thwarted by current President Obama through his decision to dissolve the United States from the Paris agreement (Pavone IR, 2018, p.36-37).

Trump's intention to withdraw America from the Paris Agreement unleashed a series of conflicting opinions on the issue. Some energy industry leaders expressed their disagreement claiming that staying in the Paris climate pact would be better for the U.S. However, with the election of President Donald Trump, the problems of science and the environment proved immediately to be a critical point for the new administration. In the article published by Pavone I.R. in 2018, the author claims that on numerous occasions, the new American president would have declared that global warming is only a deception devised by China with the aim of damaging American industries (2018, p.39). Furthermore, the idea of Trump not about environmental pollution issues does not differ much from those expressed in the past by the Bush Jr. In fact, President Trump often claimed to want to eliminate all unnecessary restrictions applied to American energy industries like the coal and oil industries. For Trump the reduction of polluting emissions must in no way harm American industries (Pavone I.R., 2018, p. 39). On 1 June 2017, new president Donald Trump publicly announced the United States of America's exit from the 2015 Paris climate agreement. He said

"the United States will withdraw from the Paris Climate Accord [...]the United States will cease all implementation of the non-binding Paris Accord and the draconian financial and economic burdens the agreement imposes on our country"

Furthermore, the president declared that he would definitively cease the implementation of contributions to the Green Climate Fund as he believes that this represents a high cost for the United States (Pavone I.R., 2018, p.41). In publicly declaring the exit of the US from the Paris agreement, Trump argued that the environmental regulations adopted by the previous Obama

administration were extremely rigid and excessive but also the main cause for the loss of several jobs in the oil industries (Pavone I.R., 2018, p.35). The current Trump administration in its public declaration shamelessly declared that the United States of America would have opted for the violation of the Paris pact in the assumption of the final exit from the contract in 2020. The violation of the pact involves the failure to observe and respect the obligations imposed by the agreement and this behavior is considered non-compliant with international laws. Through this decision, Trump has severely damaged the reputation of the United States by escaping international obligations and causing lose in state trustworthy. Reputation is a fundamental element in international relations between states as it is a mandatory compliance mechanism. Generally, states are committed to respecting their international obligations to avoid damaging their reputation. States normally respect their international duties not much for a matter of justice but mainly to maximize their own interests. Trump's unexpected and surprising decision to openly violate the Paris agreement once again confirms the irrationality of his actions. Ultimately, the current US administration focuses much more on internal consensus than on the state's international reputation. However, the president does not exclude the possibility of a future return of the United States in the Paris Agreement if a fair compromise would be found, saying:

"so, we are getting out, but we will start to negotiate, and we'll see if we can make a deal that's fair"

Following the public declaration of the exit from the agreement, several countries expressed their disagreement and disappointment towards the Trump administration that deserted the commitment and efforts of all other countries in the struggle to reduce environmental pollution. The French president Macron declared that the choice of Trump would have damaged both the United States and the rest of the planet. While German Chancellor Merkel expressed her deploration toward the US withdrawal from the Paris Agreement (Pavone I.R., 2018, p. 40-41).

4.4 Today's European market share of diesel cars

Since 2010 and for the next 7 years the global automotive industry has had constant growth in terms of new vehicles sold. However, in 2018 the OICA recorded a decrease in the sale of new motor vehicles of 604,669 units at a global level (a 0.63% less than in 2017). The decline was recorded in all regions except for America, where sales increased by 258,936 units (1% more than in 2017). The last time there was a decline in sales of new vehicles globally was

between 2008 and 2009, a period heavily influenced by the financial crisis. From the statistics published by the European organization ACEA, the percentage of diesel-powered vehicles in circulation in Europe is rapidly losing points. In fact, in the second quarter of 2017 the market share of diesel engines amounted to 45.2%, in the same period of the year 2018 there was 36.3% and finally in the second quarter of 2019 the percentage of market was further lowered recording 31.3% of the European market. The diesel-powered engines were the only ones experiencing a decline in the European automotive market. From 2017 to 2018 diesel in Europe fell by -15.5% while from 2018 to 2019 the drop was -16.4% (ACEA official website[61]).

Conclusion

Nowadays diesel-powered engines are still used by the large-scale population. Their buying market has for years been driven by the main factors of cost, consumption and vehicle performance. The pollution level option caused by engine emissions has never been a particularly determining factor in people's choice of consumption. However, as environmental pollution is a topical issue today, for which we are constantly discussing, we would expect people to be more informed, more aware and more sensitive to the problem. The Volkswagen Group car emissions scandal has alarmed many government organizations that have immediately taken steps to better control diesel engine emissions. Despite what happened, the administration of the new president Trump withdrew from the International Agreement of Paris declaring that in the United States of America precedence would be given to the growth and financial development of companies by limiting any unnecessary restrictions on emissions reduction. The withdrawal from the Paris Agreement has caused much discussion and the reputation of the US has been seriously damaged by Trump's action. From the survey carried out on 271 people it emerged that many individuals have never heard the term Dieselgate despite having declared themselves informed about the issue of vehicular pollution. Moreover, although the number of owners of diesel-powered cars is still very high, their future purchase decisions are strongly oriented towards the choice of cars powered by alternative or hybrid energies. From the analysis of the future of the automotive industry carried out by experts in the sector, it emerged that automobile production will continue to grow in proportion to population growth. Furthermore, in developing countries the

[61]https://www.acea.be/press-releases/article/fuel-types-of-new-cars-diesel-16.4-petrol-1.7-electric-35.6-in-second-quart
https://www.acea.be/press-releases/article/fuel-types-of-new-cars-diesel-15.5-petrol-19.8-electric-43.8-in-second-quar

automotive market still has plenty of room to grow and expand. This growth necessarily determines the consequent increase in the demand for powertrain energies. Vehicle traffic statistics for the past three years have seen a significant decrease in the production and sales of diesel-powered cars. This information could make us think that perhaps soon the automotive market could be completely dominated by electric cars or other eco-sustainable energies. Most transport vehicles currently in use are powered by oil or diesel (BP, 2018). There are also alternatives such as natural gas, electricity and hybrid engines that can work either with traditional fuels (oil or diesel) or with gas or electricity. In their study, Nieuwenhuis and Peter argued that the automotive industry's sales will continue to grow at least until 2030 and that most vehicles produced and sold will have diesel- or petrol-powered engines (p.26, 2015). The data collected in the study in 2012, suggested that the automotive industry would have grown by 60% by 2030 and that 94% of these vehicles will be fueled by petrol or diesel, 4% will be powered by gas and only 1% will be electric (p.26, 2015). One wonders if following the "Dieselgate" scandal, that began in 2015 (so a few years after the forecasts made by BP in 2012), the statistics have changed. The BP report (2018) shows that global energy production is directly proportionate to the growing number of populations that will reach 9.2 billion people by the year 2040. Furthermore, the prosperity of developing countries is another factor which increases the energy demand. In fact, economies like China and India represent half of the expansion of world production. Global energy demand is growing in all sectors and the transport sector accounts for 20% of this demand. However, the demand from the transport sector is slightly decreasing for several reasons. The BP report claims that urbanization of people is increasing rapidly; this means that people use less transports and consequently the energy demand decrease. Furthermore, whether on the one hand the prosperity of the economies means that the demand for transport is increasing, on the other hand the evolution of the efficiency of cars makes it possible to travel more and more kilometers with lower quantities of fuel. By 2040 it is expected that the demand for transport will be more than double but the fuel demand for the cars will be much lower than today thanks to the better efficiency of cars and motorcycles; instead, it will be on the increase for traking as there will be greater traffic in goods and less innovation in the efficiency of trucks. Another interesting data reported in the BP report (2018) is that today the demand for oil represents 94% of the total fuel demand in the transport sector and it will decrease to 85% by 2040. If we consider the data previously collected by Nieuwenhuis and Peter concerning the forecasts for 2030 there would be no difference in the consumption of diesel and petrol between 2018 and 2030. In practice the forecasts either have an advance of 12 years or a stall

is foreseen in the variation of this datum. Furthermore, by 2040 there will also be an increase in the passenger car fleet almost doubled with a total of about two billion cars, of which 300 million electric cars. In 20 years, the automotive industry will produce cars with 70% more efficiency than in 2000 (BP, 2018). In fact, a typical car with an internal combustion engine runs 100km with 3 liters, while today it requires 5 liters for the same distance (7 liters in 2000).

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